

# LUPIN

#### PADDOCK PLANNING AND PREPARATION

PLANTING

PLANT GROWTH (PHENOLOGY) AND DEVELOPMENT

NUTRITION AND FERTILISER

WEEDS AND HERBICIDES

PESTS AND INSECTS

ROOT DISEASES AND NEMATODES

**FOLIAR DISEASES** 

DESICCATION, CROP-TOPPING AND GREEN/BROWN MANURING

HARVEST

**GRAIN MARKETS** 

LUPIN AS A FEED SOURCE

**GRAIN MARKETING** 

**CURRENT RESEARCH** 

GRDC AND INDUSTRY CONTACTS





## Start here for answers to your immediate lupin crop management issues



What variety of lupin should I grow?

SOUTHERN

OVEMBER 2017



What paddock conditions suit lupin?



What fertilisers do I require?



Are there specific weed control issues?



Are the diseases of lupin manageable?



How do I manage pests and insects?







What are the essentials before and during harvest?



How do I market my lupin grain?



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ISBN: 978-1-921779-29-9



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#### 16 References





### i) MORE INFORMATION

GRDC Final Reports: <u>https://grdc.com.</u> au/research/reports

GRDC Project Summaries: <u>https://</u> grdc.com.au/research/projects

GRDC Pulse Australia 'Australian Pulse Crop Forecasts': <u>http://</u> <u>pulseaus.com.au/storage/app/media/</u> <u>industry/20160613\_AU-pulse-crop-</u> <u>forecast.pdf</u>

Lupins.org: www.lupins.org

DPIRD 'Guide to Growing Lupins': https://www.agric.wa.gov.au/lupins/ lupin-essentials-%E2%80%93growing-successful-lupin-crop

DAFWA 'Bulletin 102008 Producing Lupins': <u>http://researchlibrary.</u> agric.wa.gov.au/cgi/viewcontent. cgi?article=1009&context=bulletins

# Introduction

#### A.1 Crop overview

Australia dominates as a world lupin producer and has been responsible for about 85 percent of global supply of this pulse grain annually during the past decade.

Lupin is a winter crop, grown in Western Australia, South Australia, New South Wales and Victoria.

Production in the southern cropping region is focused on narrow leafed lupin (*Lupinus angustifolius*), also known as Australian sweet lupin, and albus lupin (*L. albus*), or white lupin.

Narrow leafed lupin suits acidic, sandy or low fertility soils and development of a range of varieties has assisted southern growers, especially in SA, to include this beneficial break crop in rotations.

In the southern region, albus lupin is grown mostly in VIC (along with narrow leafed varieties) and is best suited to fertile, well-drained and heavier soils. These varieties do particularly well on the more alkaline soils in the south of that State.

Narrow leafed lupin has major advantages as a rotational break crop in cereal cropping systems, including contributing to nitrogen (N) fixation, offering a quality stock feed product option and having potential for sale into existing high-value export markets.

Australian lupin grain production significantly contracted during the past two decades, from almost two million tonnes in 1999 to 578,400 t in 2015.<sup>1</sup>

This was mainly due to difficulties in weed control, aggravated by development of herbicide resistance in the main weed species of lupin-wheat rotations and high returns for canola as an alternative break crop.

Lupin grain production has started to increase in recent years as new varieties and management options have become available to Australian growers on the back of research, development and extension efforts.

#### A.2 Value of lupin in crop rotations

When planning lupin in a cropping rotation, key considerations include crop sequences, weed burdens and types, herbicide options and disease issues.

The ability of lupin to thrive in low nutrient soils and effectively fix N typically results in higher yielding cereal crops following a lupin crop than cereals following pastures. In turn, a lupin crop tends to yield better after cereals than a pasture.

It is recommended to avoid growing lupin immediately following lupin or pasture in sequences and to ensure good summer paddock preparation for weed control.





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#### A.3 Nutrition

The timing and rates of nutrient and fertiliser application are best planned to meet the lupin plant's growth cycle and requirements.

In southern Australia, manganese (Mn) deficiency can be particularly difficult to correct and potentially leads to split seed disorder later in the season.<sup>2</sup>

Zinc (Zn), phosphorus (P) and sulfur (S) deficiencies can significantly reduce legume production in parts of the southern region.

Most soils in this region also have low natural P levels, which can lead to poorer productivity of narrow leafed varieties in some areas.

#### A.4 Weeds and pests

Weed and pest management in southern lupin crops starts with summer and preemergence control, followed by monitoring and control measures after the crop has emerged.

Integrated pest and weed management plans are recommended. These take into account tactics including:

- » Rotations to reduce weed burdens and pest presence
- » Cultivation to eliminate food sources
- » Machinery and vehicle hygiene
- » Crop competition
- » Use of herbicides and insecticides per label recommendations.

Typically, a lupin-cereal rotation is beneficial to remove grass weeds in broadleaf lupin crops and broadleaf weeds in cereal crops.

This can also help to reduce carry-over of disease and pests.

Major weeds affecting lupin crop production in the southern region include annual ryegrass (*Lolium rigidum*), wild oats (*Avena fatua L.*), brome grass (*Bromus diandrus* and *B. rigidus*), barley grass (*Hordeum*) and wild radish (*Raphanus raphanistrum L.*).

Moves towards minimum or no-tillage farming systems with stubble retention and a changing climate have contributed to an increased impact of pests, costing the lupin industry in the southern region an estimated \$14 million in control methods annually.<sup>3</sup>

Snails, Redlegged earth mites (*Halotydeus destructor*) and aphids (*Aphididae*) are among the main pests that cause lupin crop damage in SA, NSW and VIC.

#### A.5 Disease

Foliar and root diseases are a substantial risk to yield in lupin crops.

The main production-limiting disease, anthracnose, has occurred in narrow leafed lupin crops on the Eyre Peninsula in SA, but has not been sighted in recent years. Quarantine restrictions for importation of SA lupin grain into VIC and NSW have been in place since 1996.

While SA growers should be aware of anthracnose from a marketing perspective, its risk does not affect crop management - including variety choice.

Anthracnose was reported in commercial crops in NSW in 2016 and eradication zones are set up. More information can be found at: <a href="https://www.dpi.nsw.gov.au/biosecurity/plant/recent-pest-arrivals/lupin-anthracnose">www.dpi.nsw.gov.au/biosecurity/plant/recent-pest-arrivals/lupin-anthracnose</a>.



<sup>2</sup> Lupins.org (2016) website Banding manganese fertiliser for lupins, <u>http://www.lupins.org/production/#farming</u>

<sup>3</sup> Murray, D, Clarke, M and Ronning, D (2013). The current and potential costs of invertebrate pests in grain crops, Grains Research and Development Corporation, <u>https://grdc.com.au/\_\_\_data/assets/pdf\_file/0026/159281/grdcreportcurrentpotentialcostsinvertebratepes</u> <u>ts-feb2013pdf.pdf</u>



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Phomopsis stem and pod blight, Brown leaf spot, Cucumber mosaic virus (CMV) and Sclerotinia stem and collar rot also require control in some areas of the southern region in some seasons.

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Incidence of root and hypocotyl rot diseases in southern region lupin crops has declined in the past 20 years, largely due to better variety resistance. However, these root diseases can still present significant production risk without stringent controls.

Monitoring during plant development and ensuring adequate weed and pest control can help to reduce the impacts of root and foliar diseases in lupin crops.

Fungicide treatment options can be limited for some diseases after lupin crops have germinated.

#### A.6 Plant maturity and harvest

Desiccation and crop-topping, with windrowing/swathing, to strategically apply herbicides and control crop maturity is an option with lupin crops.

But these methods can cause significant yield losses if not well-timed.

In recent years, lupin breeding and maturity development by Pulse Breeding Australia (PBA) has produced earlier maturing narrow leafed lupin varieties that are better suited to this system.

If growers choose to crop-top lupin, immediate harvest is advised after the required withholding periods are met.

In recent years, lupin breeding has assisted in release of varieties with traits for lower pod shatter to reduce losses at harvest.

It remains advisable to harvest lupin as soon as the crop is ripe to minimise potential for yield loss due to plant lodging, pod shattering or pod drop/shedding and grain quality decline.

The best harvesting window is within three weeks of maturity and when grain moisture reaches 14 percent, regardless of the outward appearance of the plant.

Harvesting below this moisture level can increase bruised and cracked seed risk and reduce germination and vigour in planting seed.

Key considerations for storage of lupin grain include moisture content and temperature control.

#### A.7 End uses

Narrow leafed lupin is predominantly used as a livestock feed source for grain and the crop stubbles for livestock grazing. Albus lupin is mainly used for human consumption in Middle East markets.

Lupin grain as a stock feed is cost effective, high in protein and metabolisable energy and low in starch levels. It can be safely consumed by ruminants (sheep and cows) and monogastrics (pigs and poultry). There is also increasing interest in lupin grain from the aquaculture sector.

Caution is advised when grazing lupin stubbles due to the risk of lupinosis developing in livestock.

This disease can damage the liver, cause loss of appetite and/or lead to poor production and possible death of affected animals.

There is a small, but increasing, interest in the use of lupin grain (as flakes and flour) for human food consumption.





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#### A.8 Marketing

Industry standards apply to any sales of lupin grain for domestic or international markets.

In addition, some international markets have extra quarantine restrictions.

The standards applied in Australia, known as Australian Pulse Standards, address seed defects, disease and foreign matter.

In addition to these standards, lupin seed/grain entering VIC and NSW from SA or WA must have appropriate documentation and accreditation to minimise risks of anthracnose entering those States.

Lupin exports from Australia predominantly come out of WA and the biggest markets are South Korea, Japan and the Netherlands for narrow leafed varieties and Egypt for albus lupin.





## **i** MORE INFORMATION

Pulse Australia 'Lupins in South Australia and Victoria': <u>http://www.</u> <u>pulseaus.com.au/storage/app/media/</u> <u>crops/2007\_Lupins-SA-Vic.pdf</u>

National Variety Trials 'Sowing Guides': <u>http://www.nvtonline.com.au/</u> <u>crop-guides/sa/</u>

Agriculture Victoria, 'Growing Lupin': <u>http://agriculture.vic.gov.au/</u> <u>agriculture/grains-and-other-crops/</u> <u>crop-production/growing-lupin</u>

Pulse Breeding Australia: <u>www.grdc.</u> <u>com.au/Research-and-Development/</u> <u>Major-Initiatives/PBA/PBA-Varieties-</u> <u>and-Brochures</u>

GRDC 'Ground Cover Supplement -Flexible Farming': <u>http://gc-</u> <u>supplement.realviewdigital.com/</u> ?iid=66229&startpage=page 0000015#folio=8

# Paddock planning and preparation

#### 1.1 Overview

Including lupin in crop rotations with cereals can be more profitable than continuous cereal production in parts of the southern region.

Other benefits of growing this pulse crop are to provide a cereal disease and pest break, increase supplies of organic soil nitrogen (N), create more options for weed control and provide livestock feed in mixed farming systems.

Lupin crops effectively fix atmospheric N in symbiosis with bacteria and can take up phosphorus (P) efficiently from the soil.

The two main types grown in the southern region are the Australian sweet lupin, or narrow leafed lupin (*Lupinus angustifolius*), and albus lupin (*L. albus*), or white lupin.

Each has separate end uses and markets and different growth requirements due to the various soil types, rainfall zones and environments found across southern Australia.

#### 1.2 Variety selection

The narrow leafed lupin is the main type grown in South Australia, Victoria and New South Wales.

This species is highly suited to acidic, sandy or low-fertility soils where other pulses may do poorly. Different varieties are suitable for different regional areas, depending on the amount of annual rainfall received.

Albus lupin is produced across all three Australian lupin growing regions, but in a much smaller area.

This species is best suited to fertile, well drained, heavier soils and has slightly better adaptation than narrow leafed varieties to alkaline soils.

Albus lupin tends to grow poorly in low rainfall areas and on infertile, deep sand or waterlogged soils. In the southern region, albus lupin is grown mostly in NSW and VIC.

The varieties of lupin grown in the southern region, agronomic traits and disease ratings of these varieties are outlined in Table 1.<sup>1</sup>



Couchman, J, Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>www.grdc.com.au/NVT-Victorian-Winter-Crop-Summary</u>



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Table 1: Lupin variety agronomic and disease guide<sup>2</sup>

Variety	Flowering time	Height	Lodging	Pod Shattering	Drought Tolerance	Aphid Resist	Brown Leaf Spot	Pleiochaeta root rot	CMV seed tranmit	Anthracnose	Phomopsis – Stem	Phomopsis – Pod
Narrow leafed												
PBA Bateman <sup>∅</sup>	E/VE	Т	MSMR	MRMS		R	MS	MR	MRMS	MR	MR	MR
Jenabillup <sup>⊕</sup>	Μ	Т	MR	MS	MR	MR	MRMS	R	MRMS	S	MS	R
Jindalee	M-L	М	R	MR	MS		MRMS	R	MS	S	R	R
Mandelup <sup>⊕</sup>	VE	Т	MS	MS	MR	R	MS	R	MS	MR	R	MRMS
PBA Barlock®	E	М	MR	R		R	MS		RMR	R	MR	R
PBA Gunyidi <sup>⊕</sup>	VE	Μ	MS	R	MR	R	MS	R	MRMS	MR	R	R
PBA Jurien <sup>©</sup>	VE	Т	MS	MR		R	MS		MRMS	R	R	MR
Quilinock <sup>⊕</sup>	E	S	MS	MR	MR	MS	MRMS	R	MS	SVS	MRMS	MS
Wonga	E-M	Μ	MR	R	MS	R	MS	R	R	R	R	R
Albus lupin												
PBA Murringo <sup>⊕</sup>	mid	Μ	MSMR			R		MR		VS	Intermediate	
Kiev Mutant	E	М	R		MS	S	MS	VS	Immune	VS	MR	S
Luxor®	E-M	M-T	R		MS	S	MR	R	Immune	VS	MR	S
Rosetta	M-L	т	R		MS	S	MR	MR	Immune	VS	MR	S

Flowering time; VE=very early, E=early, M=mid, L=late Height; S=short, M=medium, T=tall Lodging and disease reactions; R = Resistant RMR = Resistant to moderately resistant MR = Moderately resistant MRMS = Moderately resistant to moderately susceptible MS = Moderately susceptible MSS = Moderately susceptible to susceptible S = Susceptible SVS = Susceptible to very susceptible VS = Very susceptible.



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Couchman, J, Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>www.grdc.com.au/NVT-Victorian-Winter-Crop-Summary</u> 2



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## i MORE INFORMATION

Pulse Australia 'Australian pulse varieties': <u>http://pulseaus.com.</u> <u>au/storage/app/media/crops/</u> <u>pulses/2016\_Pulse-Variety-Charts-</u> <u>web.pdf</u>

PBA Bateman<sup>(b)</sup> variety management guidelines: <u>http://www.seednet.com.</u> <u>au/product-profile-92\_658.html</u>

NVT Victorian Winter Crop Summary: www.grdc.com.au/NVT-Victorian-Winter-Crop-Summary



#### 1.3 Narrow leafed lupin varieties

#### 1.3.1 PBA Bateman<sup>()</sup>



**Figure 1:** PBA Bateman<sup> $\phi$ </sup> This is a new variety released for southern region planting in 2017.

(SOURCE: Pulse Breeding Australia)

PBA Bateman<sup> $\phi$ </sup> is a narrow leafed lupin line released for southern region planting in 2017 under Pulse Breeding Australia (PBA) through Seednet.

It was bred by the PBA Lupin Breeding Program, led by the Department of Primary Industries and Regional Development (DPIRD) in WA.

In NSW National Variety Trials (NVT) it has been found to be high yielding, including in years of high pressure from Bean yellow mosaic virus (BYMV) and Cucumber mosaic virus (CMV).

PBA Bateman<sup> $\phi$ </sup> was one of several breeding lines to out-yield Mandelup<sup> $\phi$ </sup> by between 25 and 38 percent in four National Lupin Initiative trials in NSW in 2015.

PBA advises this variety has significant yield improvements over current narrow leafed varieties in the majority of lupin growing regions in NSW and SA.<sup>3</sup> Variety information for PBA Bateman<sup>(b)</sup> is available at: <u>http://www.seednet.com.au/product-profile-92\_658.html</u>









## i) MORE INFORMATION

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PBA Jurien<sup>(1)</sup> variety management guidelines: <u>http://www.pulseaus.com.</u> <u>au/storage/app/media/crops/2015\_</u> <u>VMP-AustLupin-PBAJurien.pdf</u>





**Figure 2:** PBA Jurien<sup>®</sup> is a variety released in Western Australia in 2015 that performs well across southern Australia.

(SOURCE: GRDC)

This variety originated in WA and was released in 2015.

It has performed well across all lupin growing regions of Australia, with consistently higher yields in national trials in recent years compared to many older lupin varieties.

PBA Jurien<sup>()</sup> combines strong disease resistance with high yield potential.

In SA, the lower Eyre Peninsula, south east and upper Eyre Peninsula have had superior yield results in trials of this variety.

In VIC, yield results in trials have been similar to PBA Barlock<sup> $\phi$ </sup>, PBA Gunyidi<sup> $\phi$ </sup>, Jenabillup<sup> $\phi$ </sup> and Mandelup<sup> $\phi$ </sup> (with some regional variation).<sup>4,5</sup>

Variety management guidelines for PBA Jurien<sup> $\Phi$ </sup> are available on the Pulse Australia website at: http://www.pulseaus.com.au/storage/app/media/crops/2015\_VMP-AustLupin-PBAJurien.pdf

4 South Australian Research and Development Institute (2016) Sowing Guide, SARDI, <u>http://www.nvtonline.com.au/wp-content/uploads/2016/03/SA-sowing-guide-2016-to-res.pdf</u>



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<sup>5</sup> Pulse Breeding Australia (2016) PBA Varieties and brochures, <u>www.grdc.com.au/Research-and-Development/Major-Initiatives/PBA/PBA-Varieties-and-Brochures</u>



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PBA Barlock<sup>(b)</sup> Variety management guidelines: <u>http://www.pulseaus.com.</u> au/storage/app/media/crops/2013\_ VMP-AustLupin-PBA-Barlock.pdf





**Figure 3:** *PBA Barlock<sup>®</sup> is a high yielding variety for most regions of SA and VIC.* (SOURCE: PBA)

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PBA Barlock $^{\phi}$  is high yielding and has improved yield potential for most regions of SA and VIC, compared to older narrow leafed varieties.

Released in 2013, it is an early flowering and maturing variety, with moderate resistance to lodging in high rainfall areas and improved pod shatter resistance than the previously popular varieties Coromup<sup>6</sup> and Tanjil<sup>6</sup>.

This variety features resistance to aphids and has a strong disease resistance profile, including to anthracnose (*Colletotrichum lupini*) and phomopsis (*Diaporthe toxica*), with only mild susceptibility to Brown leaf spot (*Pleiochaeta setosa*).<sup>67</sup>

Variety management guidelines for PBA Barlock<sup>()</sup> are available on the Pulse Australia website at: <u>http://www.pulseaus.com.au/storage/app/media/crops/2013\_VMP-AustLupin-PBA-Barlock.pdf</u>



<sup>6</sup> South Australian Research and Development Institute (2016) Sowing Guide, SARDI, <u>http://www.nvtonline.com.au/wp-content/uploads/2016/03/SA-sowing-guide-2016-lo-res.pdf</u>

<sup>7</sup> Pulse Breeding Australia (2016) PBA Varieties and brochures, <u>www.grdc.com.au/Research-and-Development/Major-Initiatives/PBA/PBA-Varieties-and-Brochures</u>



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## i MORE INFORMATION

PBA Gunyidi<sup>®</sup> variety management guidelines: <u>http://www.pulseaus.com.</u> <u>au/storage/app/media/crops/2012\_</u> <u>VMP-Austlupin-PBAGunyidi.pdf</u>





**Figure 4:** Released in WA in 2011, PBA Gunyidi<sup>(b)</sup> has high yield potential for the southern region.

(SOURCE: GRDC)

PBA Gunyidi<sup> $\phi$ </sup>, released in WA in 2011, has high yielding potential across VIC and SA and features early flowering and maturing qualities.

It has improved pod shattering resistance compared to Mandelup<sup> $\phi$ </sup> and Jenabillup<sup> $\phi$ </sup>, which can reduce risks of yield loss if harvest is delayed.

It has promising resistance (in varying levels) to aphids, anthracnose and phomopsis, but PBA Gunyidi<sup>()</sup> does have mild susceptibility to Brown leaf spot in some areas.<sup>8,9</sup>

Variety management guidelines for PBA Gunyidi<sup>®</sup> are available on the Pulse Australia website at: <u>http://www.pulseaus.com.au/storage/app/media/crops/2012\_VMP-Austlupin-PBAGunyidi.pdf</u>

8 South Australian Research and Development Institute (2016) Sowing Guide, SARDI, <u>http://www.nvtonline.com.au/wp-content/uploads/2016/03/SA-sowing-guide-2016-lo-res.pdf</u>



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<sup>9</sup> Pulse Breeding Australia (2016) PBA Varieties and brochures, <u>www.grdc.com.au/Research-and-Development/Major-Initiatives/PBA/PBA-Varieties-and-Brochures</u>



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Jenabillup<sup>0</sup> variety management guidelines: <u>http://www.pulseaus.com.</u> <u>au/storage/app/media/crops/2011\_</u> <u>VMP-NLlupin-Jenabillup.pdf</u> 1.3.5 Jenabillup<sup>()</sup>



## **Figure 5:** Jenabillup<sup>()</sup> is a mid-maturing variety that grows well in medium and high rainfall areas.

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(SOURCE: GRDC)

Jenabillup $^{\oplus}$  is a mid-maturing variety, well suited for stock feed and some niche food markets and with adaptation to all rainfall zones.

It grows best in medium and high rainfall areas of SA and was released in that state in 2011.

This variety has moderate resistance to black pod syndrome (caused by BYMV infection) and Brown leaf spot and moderate resistance to seed transfer of CMV.

Jennabillup<sup> $\Phi$ </sup> tends to perform better than Mandelup<sup> $\Phi$ </sup> in longer growing season areas, as its extended flowering window can assist with increasing yields. But this makes it less suitable for crop-topping for weed control.<sup>10,11</sup>

Variety management guidelines for Jenabillup<sup>()</sup> are available on the Pulse Australia website at: <a href="http://www.pulseaus.com.au/storage/app/media/crops/2011\_VMP-NLlupin-Jenabillup.pdf">http://www.pulseaus.com.au/storage/app/media/crops/2011\_VMP-NLlupin-Jenabillup.pdf</a>

10 Couchman, J, Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>www.grdc.com.au/NVT-Victorian-Winter-Crop-Summary</u>



<sup>11</sup> South Australian Research and Development Institute (2016) Sowing Guide, SARDI, <u>http://www.nvtonline.com.au/wp-content/uploads/2016/03/SA-sowing-guide-2016-lo-res.pdf</u>



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Mandelup<sup>()</sup> variety management guidelines: <u>http://www.pulseaus.com.</u> <u>au/storage/app/media/crops/2011\_</u> <u>VMP-NLlupin-Mandelup.pdf</u>





**Figure 6:** *Mandelup*<sup> $\phi$ </sup> *is a solid performer across most of the southern region.* 

Mandelup $^{\phi}$  is a robust and high yielding narrow leafed lupin variety with early maturity, making it suitable for crop-topping.

Released in 2004, it consistently out-yielded earlier-released narrow leafed varieties in low and medium rainfall zones. But it is not recommended for high rainfall areas, as it has a tendency to lodge with high productivity.

Yield potential tends to be marginally higher in VIC's north east, SA's mid north and the lower Eyre Peninsula, but it is considered a solid performer across southern region rainfall zones.

Mandelup $^{\Phi}$  has a good disease and insect resistance profile, featuring mild resistance to anthracnose and resistance to aphids.

Reported issues with Mandelup<sup> $\Phi$ </sup> include pod shatter with delayed harvest and poorer seed germination rates than in some other varieties.<sup>12,13</sup>

Variety management guidelines for Mandelup<sup>()</sup> are available on the Pulse Australia website at: <u>http://www.pulseaus.com.au/storage/app/media/crops/2011\_VMP-NLlupin-Mandelup.pdf</u>



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<sup>12</sup> Couchman, J. Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>https://grdc.com.au/resources-and-publications/ail-publications/publications/2017/03/nvt-victorian</u> winter-crop-summary

<sup>13</sup> South Australian Research and Development Institute (2016) Sowing Guide, SARDI, <u>http://www.nvtonline.com.au/wp-content/uploads/2016/03/SA-sowing-guide-2016-to-res.pdf</u>



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Jindall variety information: <u>http://</u> pulseaus.com.au/blog/post/2017pulse-variety-guide

## **i** MORE INFORMATION

Quilinock<sup>®</sup> variety information: <u>https://</u> www.ipaustralia.gov.au/sites/g/files/ net856/f/journals/pvj\_29\_3.pdf

#### 1.3.7 Jindalee

Jindalee is a late maturing variety, flowering later in the season than the newer varieties.

It tends to yield higher than Wonga in many areas and suits medium to high rainfall zones in SA, if anthracnose resistance is not essential. This variety, released in 2000, has intermediate susceptibility to anthracnose.

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Jindalee does not typically handle a dry finish well because of its tendency to flower later, but it does have resistance to phomopsis on stem and pods and is moderately resistant to Brown leaf spot.<sup>14</sup>

Variety information for Jindalee is available at: <u>http://pulseaus.com.au/blog/post/2017-pulse-variety-guide</u>

#### 1.3.8 Quilinock<sup>()</sup>



**Figure 7:** Quilinock<sup>()</sup> has mostly been superseded in the south.

Released in 1999, Quilinock  $^{\!\!\!(\!\!\!\!\!\!\!\!)}$  has been predominantly superseded as an option in most areas of the southern region.

It is early flowering and suits low and medium rainfall areas.

It is susceptible to very susceptible to anthracnose and has poorer phomopsis resistance than most other varieties.

It has poor tolerance to metribuzin herbicide.

There are limited quantities of this variety now grown in the southern region due to anthracnose susceptibility.  $^{\rm 15}$ 

Variety information for Quilinock<sup>®</sup> is available at: <u>https://www.ipaustralia.gov.au/sites/g/</u> files/net856/f/journals/pvj\_29\_3.pdf



<sup>14</sup> Couchman, J, Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>www.grdc.com.au/NVT-Victorian-Winter-Crop-Summary</u>

<sup>15</sup> Couchman, J, Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>www.grdc.com.au/NVT-Victorian-Winter-Crop-Summary</u>



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Wonga variety information: <u>http://</u> <u>pulseaus.com.au/blog/post/2017-</u> <u>pulse-variety-guide</u> 1.3.9 Wonga



**Figure 8:** Wonga is an older variety but may have a place in high disease risk areas. (SOURCE: GRDC)

Wonga, released in 1997, is an early flowering, moderate yielding lupin with anthracnose resistance and moderate resistance to phomopsis.

It matures slower than Mandelup  $^{\! \! \! b}$  and is suited to medium rainfall districts.

Wonga is one of the older varieties but its resistance properties are relevant to growers at risk – despite a tendency to be out-yielded by other varieties.<sup>16</sup>

Variety information for Wonga is available at: <u>http://pulseaus.com.au/blog/post/2017-pulse-variety-guide</u>

#### 1.4 Albus lupin varieties

#### 1.4.1 Murringo<sup>()</sup>

Murringo $^{\phi}$  is the newest and highest yielding albus lupin variety for southern and northern grain growing regions of Australia.

Bred by DPIRD as a cross between a germplasm accession from the Azores Islands and the Russian variety, Vladimir, it was released in 2017 through Seednet.

Murringo $^{\circ}$  is best suited to medium and high rainfall lupin growing regions of NSW, but can also be grown in parts of VIC and SA.

This variety is suited to a late-April to mid-May sowing and is mid-flowering, with a slightly longer maturity time than  ${\rm Luxor}^{\rm do}$ 

It has moderate resistance to pleiochaeta root rot and phomopsis, but is susceptible to anthracnose.

Grain quality and its pure white colour makes Murringo<sup>(b)</sup> well suited to albus human consumption markets. Seed size is similar to Luxor<sup>(b)</sup> and Amira<sup>(b)</sup>.

Variety management guidelines for Murringo<sup>(b)</sup> are available at: <u>www.seednet.com.au/</u> product-profile-92\_649.html



Murringo<sup>(+)</sup> variety management guidelines: <u>http://www.seednet.com.</u> <u>au/product-profile-92\_649.html</u>



<sup>16</sup> South Australian Research and Development Institute (2016) Sowing Guide, SARDI, <u>http://www.nvtonline.com.au/wp-content/uploads/2016/03/SA-sowing-guide-2016-lo-res.pdf</u>





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### i) MORE INFORMATION

Luxor<sup>b</sup> variety management guidelines: <u>http://www.pulseaus.com.</u> <u>au/storage/app/media/crops/2009\_</u> <u>VMP-AlbusLupin-Luxor.pdf</u>

**MORE INFORMATION** 

Rosetta variety management

VMP-Albuslupin-Rosetta.pdf

guidelines: http://www.pulseaus.com.

au/storage/app/media/crops/2009\_



**Figure 9:** Luxor<sup>(b)</sup> was the albus variety developed to replace Kiev Mutant and has improved resistance to pleiochaeta root rot.

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(SOURCE: GRDC)

Released in 2008, Luxor<sup>®</sup> was the albus variety developed to replace Kiev Mutant and has improved resistance to pleiochaeta root rot (caused by the fungus *Pleiochaeta setosa*).

It is slightly taller than Kiev Mutant and is suitable for lower to medium rainfall regions and high rainfall regions where pleiochaeta root rot can be a problem.

 $Luxor^{\oplus}$  is 100 percent sweet and should not be grown within two kilometres of other albus varieties to avoid contamination with bitter lines.  $^{17}$ 

Variety management guidelines for Luxor<sup>()</sup> are available on the Pulse Australia website at: <u>http://www.pulseaus.com.au/storage/app/media/crops/2009\_VMP-AlbusLupin-Luxor.pdf</u>

#### 1.4.3 Rosetta

Rosetta, released in 2007, is recommended for medium to high rainfall areas of the southern region and is a longer season variety.

It is best suited to cool environment parts of VIC and SA and has good Brown leaf spot resistance.

This variety was released for its improved yield over Kiev Mutant and its 100 percent sweet status for export markets means it should not be grown near other albus varieties.<sup>18</sup>

Variety management guidelines for Rosetta are available on the Pulse Australia website at: <u>http://www.pulseaus.com.au/storage/app/media/crops/2009\_VMP-Albuslupin-Rosetta.pdf</u>

17 Couchman, J, Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>www.grdc.com.au/NVT-Victorian-Winter-Crop-Summary</u>

18 Couchman, J, Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>www.grdc.com.au/NVT-Victorian-Winter-Crop-Summary</u>







## (i) MORE INFORMATION

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Kiev Mutant variety information: <u>http://</u> <u>pulseaus.com.au/blog/post/2017-</u> <u>pulse-variety-guide</u>

#### 1.4.4 Kiev Mutant



Figure 10: *Kiev Mutant has largely been replaced.* (SOURCE: GRDC)

Kiev Mutant was once the most widely grown albus lupin variety in southern Australia, but has now been virtually replaced by newer lines.

It is a vigorous grower, flowers early and matures later than narrow leafed varieties.

Kiev Mutant requires annual rainfall higher than 450 mm to yield well, but does not handle waterlogged conditions. Alkaloid testing of seed is required.<sup>19</sup>

Variety information for Kiev Mutant is available on the Pulse Australia website at: <a href="http://pulseaus.com.au/blog/post/2017-pulse-variety-guide">http://pulseaus.com.au/blog/post/2017-pulse-variety-guide</a>

#### 1.5 Soil types and paddock selection

Narrow leafed lupin varieties suit soils with low free lime levels (up to 4 percent) and tend to experience poor growth on hard setting or shallow soils (less than 25 cm) that prevent crop root penetration.

These types are most suited to acid soils with a pH as low as 4 (in Calcium Chloride or  $CaCl_2$ ) formed with sand, or sand over clay, and well-structured loam soils. Alkaline soils up to pH 8.5 are also suitable.<sup>20</sup>

Paddock soil testing for acidity (pH) should be conducted in several locations and at several depths.

This can be carried out by using professional soil testing services.

When growing lupin, it is advised that the top 40 cm of the soil profile should have no, or very low, free lime (no acid fizz reaction).

Albus lupin is typically only suited to heavy, fertile and free-draining soils in the southern region.

These varieties are sensitive to waterlogging and tend to grow poorly on sandy soils.

Albus lupin can achieve higher yields than narrow leafed varieties in some areas, but frost sensitivity and anthracnose risk can be a concern in susceptible zones.

## (i) MORE INFORMATION

DPIRD 'Lupin Essentials': https://www.agric.wa.gov.au/lupins/ lupin-essentials-%E2%80%93growing-successful-lupin-crop



<sup>19</sup> Couchman, J, Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>www.grdc.com.au/NVT-Victorian-Winter-Crop-Summary</u>

<sup>20</sup> White, P, French, B, McLarty, A (2008) Producing Lupins. Department of Agriculture and Food WA Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>



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#### **1.6** Rotation and crop sequence considerations

Lupin survives on soils with low N levels, effectively 'fixes' atmospheric N in symbiosis with rhizobia bacteria and can take up P efficiently from the soil.

Lupin will typically yield better after cereals than pasture. In turn, cereal yields tend to be greater after lupin crops than after pasture.

Growing successive lupin crops is not recommended due to risk of disease, particularly pleiochaeta root rot.

If this is the intention, it is advised to remove as much lupin stubble as possible to reduce disease risk carry over, treat the seed with registered fungicides and direct drill.<sup>21</sup>

#### 1.7 Weed and herbicide considerations

Paddock preparation for lupin starts in the summer, as crop germination and early growth can be adversely affected where melons (such as *Cucumis myriocarpus*) and other summer weeds are present. Camel melon (*Citrullus lanatus*) residue can also cause allelopathic affects to the crop.

Lupin crops can be affected by herbicide residues where rainfall has been insufficient in both summer and the previous growing season.

It is advised that this is considered when planning lupin in a rotation, along with the paddock weed burden if a knockdown is not possible.

Consideration of the herbicide label for plant-back periods should be given, as well as soil pH, free lime and rainfall levels.

Lupin has particular sensitivity to group B (sulfonamide) residues and, in high pH soils, some sulfosulfuron active residues can create damage.

All pulses, including lupin, are vulnerable to Group I phenoxy (2,4-D amine and MCPA) residues, particularly in sandy soils with low rates of microbial breakdown.

Clopyralid is another Group I active that has shown significant residual effects in lupin crops the following season after summer application in some areas.

Group I amicide formulations tend to result in more residual issues than ester formulations. Residue issues arising from the use of some newer pre-emergent herbicide options, such as the Group C terbuthylazine and Group K dimethenamid, are discussed in more detail in Chapter 5.

An integrated weed management (IWM) plan that incorporates herbicide, cultural and physical measures will be most effective for suppressing weeds, lowering weed seedbanks and prolonging herbicide sustainability in lupin crops.



## **i** MORE INFORMATION

WeedSmart 10-point Plan: www.weedsmart.org.au

GRDC 'Integrated Weed Management': www.grdc.com.au/IWM

Pulse Australia 'Minimum re-cropping intervals and guidelines': <u>www.</u> <u>pulseaus.com.au/growing-pulses/</u> <u>publications/residual-herbicides</u>

<sup>21</sup> White, P, French, B, McLarty, A (2008) Producing Lupins. Department of Agriculture and Food WA Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cqi/viewcontent.cgi?article=1009&context=bulletins</u>



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## (i) MORE INFORMATION

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DPIRD 'Machinery and Harvest Tips': <u>https://www.agric.wa.gov.</u> <u>au/lupins/amira-anthracnose-</u> resistant-albus-lupin-western-<u>australia?page=0%2C2#smart</u> <u>paging\_toc\_p2\_s1\_h3</u>

DPIRD 'Lupin Essentials': <u>https://</u> www.agric.wa.gov.au/lupins/ lupin-essentials-%E2%80%93growing-successful-lupincrop?page=0%2C4#smartpaging\_ toc\_p4\_s2\_h2



GRDC 'Stored Grain': http://storedgrain.com.au/

#### 1.8 Disease and pest considerations

Most of the newer narrow leafed and albus lupin varieties have reasonable levels of disease resistance.

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But it is recommended to have narrow leafed variety seed tested for CMV and anthracnose and albus seed tested for anthracnose.

Narrow leafed lupin tend to be susceptible to Brown leaf spot. To avoid other viruses, sowing lupin adjacent to legumes or pastures is not recommended. Most of the current narrow leafed varieties have phomopsis resistance, but significant rain on the plants while maturing or after harvest can prompt disease development.

It is advised that care be taken if this occurs and there is intent to graze lupin stubbles, or feed lupin seed to livestock, to reduce risks of lupinosis (caused by the fungus *Diaporthe toxica*).

If a paddock has a history of lupin disease, it may be best to fallow it or sow an alternative crop to allow the disease to die back.<sup>22</sup>

#### 1.9 Machinery considerations

Successful lupin growing requires use of quality seed and careful seed handling, with particular attention to any auger or seeder mechanisms that can damage grains. Tubulators, or belt elevators, can help to reduce this problem.

Seeding equipment should be capable of sowing the seed without blocking and modifications to seed tubes and dividing heads may be required, as well as changes to the metering mechanisms.

Trials suggest seed yields of narrow leafed lupin are not affected by tillage systems. This means lupin has widespread suitability for a range of farming practices.<sup>23</sup>

During harvesting, care should be taken to avoid pod shattering as lupin enters the header from the cutter bar. It is advised to pay attention to points where there is contact plant on plant, reel on crop or if there is poor removal of cut material. Harvesting in higher humidity situations, such as early mornings, and avoiding extreme heat can help reduce losses from harvest pod shatter in lupin. To prevent the spread of viruses and certain diseases, such as anthracnose, the hygiene and regular cleaning of harvest equipment is important.<sup>24</sup>

#### 1.10 Seed quality and germination issues

If lupin seed is coming into VIC or NSW from WA or SA, extra vigilance might be required or seed tested for anthracnose (which only occurs in these two states) to avoid spread.

It is advised that seed being retained on-farm for subsequent sowing should come from paddocks that are harvested first to ensure best quality and germination rates, especially if grain moisture levels are above 11.5 percent at harvest.

Seed with moisture levels above 13 percent should not be stored in a steel silo. Instead, it might be beneficial to dry the grain to ensure viability.<sup>25</sup>

- 22 DPIRD (2016) Lupin Essentials Growing a Successful Lupin Crop, DAFWA, <u>https://www.agric.wa.gov.au/lupins/lupin-essentials-</u> %E2%80%93-growing-successful-lupin-crop
- 23 White, P, French, B, McLarty, A (2008) Producing Lupins. Department of Agriculture and Food WA Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>
- 24 DPIRD (2016) Lupin Essentials Growing a Successful Lupin Crop, DAFWA, <u>https://www.agric.wa.gov.au/lupins/lupin-essentials-</u> %E2%80%93-growing-successful-lupin-crop
- 25 DPIRD (2016) Lupin Essentials Growing a Successful Lupin Crop, DAFWA, <u>https://www.agric.wa.gov.au/lupins/lupin-essentials-%E2%80%93-growing-successful-lupin-crop</u>





## i) MORE INFORMATION

GRDC 'Inoculating Legumes: A Practical Guide': <u>https://grdc.com.</u> <u>au/Resources/Bookshop/2015/07/</u> <u>Inoculating-Legumes</u>

GRDC 'Grain Legume Handbook – Inoculants': <u>www.grdc.com.au/</u> <u>grainlegumehandbook</u>

GRDC 'Inoculating Legumes: The Back Pocket Guide': <u>https://grdc.com.</u> <u>au/GRDC-BPG-InoculatingLegumes</u>

GRDC 'Rhizobial Inoculants' Fact Sheet: <u>https://grdc.com.au/GRDC-FS-</u> <u>RhizobialInoculants</u>

GRDC Tips and Tactics 'Legumes and Nitrogen Fixation': <u>https://grdc.com.</u> <u>au/tt-legume-n-fixation</u>

# Planting

#### 2.1 Overview

The ability of lupin and other legumes to fix their own nitrogen (N) make them an attractive break crop in rotations across Australia.

However, lupin crops require specific soil types and planting, inoculant, row spacing and seeding practices to ensure growers are able maximise growth and N fixation.

#### 2.2 Inoculants

- Rhizobia inoculation with the lupin-specific rhizobia can increase lupin yields and N fixation
- Gains are highest in soil with no, or few, rhizobia
- Treat seed for paddocks sown to lupin for the first time
- Treat seed for neutral/alkaline soils every time a lupin crop is grown
- Treat seed for acidic soils every five years after a lupin crop
- Formulation options include peat, clay and peat granules, freeze-dried cultures and liquids

Rhizobia are soil-dwelling root nodule bacteria that 'fix' atmospheric N in a form plants can use.

A fundamental characteristic of lupin (and other cultivated legumes) grown in Australia is the capacity to form a symbiotic relationship with these rhizobia.

This provides the total N requirements of the lupin plant, making it independent of the need for soil and fertiliser N, and injects N to the agricultural system for subsequent crops.

Many Australian soils do not naturally contain rhizobia that form effective N-fixing symbioses with introduced lupin species and other legume crops, which has created a need to inoculate lupin seed with appropriate rhizobia.

This inoculation increases lupin plant nodulation and biomass, grain production and yields, N fixation and post-crop soil nitrate levels to benefit subsequent crops.

All seed planted into paddocks that have not previously been sown to lupin requires inoculation.

On acidic soils (with a pH below 6.5 calcium chloride, or  $CaCl_2$ ), after a well-nodulated lupin crop has been grown, inoculation may not be required for five years.

If more than five years has passed between growing lupin crops on these soils, seed should be inoculated.

On neutral and alkaline soils (pH above  $6.5 \text{ CaCl}_2$ ), the rhizobia do not survive in the soil for long and seed must be inoculated every time a lupin crop is sown.

Choice of inoculant group is critical for effective nodulation and N fixation to occur.

Common forms of inoculant are moist peat and dry clay granules, which produce very good nodulation in lupin if handled and applied according to the manufacturer's instructions.

Inoculants contain high numbers of living bacteria that need to be maintained and protected from heat and excessive sunlight to optimise effectiveness.





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As shown in Table 1, common inoculants for lupin include moist peat, in-furrow water injection or dry clay granular forms.

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#### Table 1: Common inoculants for lupin.1

Inoculant type	Applied to-	Suitable for dry sowing/ drying soil	Compatibility with seed applied fungicide	Time to sow after inoculation	Preparation or machinery requirements
Peat slurry	Seed	No	Some. Check the label	24 hours	Pre-sowing
	Seed furrow/ below seed	No	Yes	_	Liquid applicator on seeder
Freeze dried	Seed	No	No	Within hours	Pre-sowing
Granular inoculum	Seed furrow/ below seed	Yes	Yes	_	Separate seed box at sowing
Liquid injection (peat or freeze)	Seed furrow	No	Yes	Within hours	Liquid applicator on seeder

Nodule number can be assessed 10-12 weeks after sowing. If a nodule is cut open and the internal flesh appears pink, this indicates the nodule is actively fixing N.

Results from 2016 trials in south eastern Australia show liquid and granular rhizobia inoculants have some practical advantages in being easy to apply and separating rhizobia from potentially harmful seed-applied pesticides.

At two out of eight trial sites, inoculation significantly improved lupin crown nodulation from 0.05 to 13 nodules per plant. Nitrogen fixation increased by 175 kilograms of N  $\,$ per hectare at one site. For full results from these trials go to: https://link.springer.com/ article/10.1007/s11104-017-3317-72.



Pulse Australia, Australian Pulse Bulletin (2016) Pulse Inoculation Techniques, http://pulseaus.com.au/growing-pulses/publications/ pulse-inoculation

University of Adelaide, AgriBio Agriculture Victoria, Latrobe University, CSIRO (2017), Legume inoculant application methods: effects on nodulation patterns, nitrogen fixation, crop growth and yield in narrow-leaf lupin and faba bean, <a href="https://iink.springer.com/article/101007/s11104-017-3317-7">https://iink.springer.com/article/101007/s11104-017-3317-7</a>





**Figure 1:** Nodulation failure in the paddock can lead to scattered nodulated plants and patchy lupin crops.

(SOURCE: DPIRD)

#### 2.2.1 Peat inoculum

This is a traditional method of applying rhizobia to lupin seed. Label directions are important and caution should be taken in regards to adding insecticides, fungicides, herbicides, detergents or fertilisers, as these can be toxic to the rhizobia.

Bacteria in peat cultures is also vulnerable to damage from heat and direct sunlight, but will survive well if refrigerated at about 5°C until used (it is advised not to freeze this material).

Peat inoculum can be applied to lupin seed using low pressure systems, such as auger mixing.

#### 2.2.2 In-furrow water injection

Inoculation with peat slurry into the seed row is gaining in popularity in the southern region, as this is well adapted to modern machinery and pulse growing systems.

It is suitable when machines are set up for liquid N application on cereals, or where fungicides are used to treat seeds prior to sowing.

This method requires at least 80 Litres of water per hectare. The solution is sprayed into the soil.

It has the convenience of being dissolvable and does not require filtering, but caution is required before mixing with any fungicides.



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#### 2.2.3 Granules

Granule forms of inoculant can vary from dry or moist, uniform or inconsistent to powdery, coarse or fine.

These products are applied similarly to fertiliser as a solid in the seed furrow or near to seed.

Granules contain fewer rhizobia than peat-based inoculants and need to be applied at higher application rates – from about four kilograms per hectare to  $10 \text{ kg/ha.}^3$ 

Some products can be mixed with fertiliser if it is drilled with the seed and not deep-banded.

#### 2.3 Time of sowing

- Early sowing optimises yields and profits
- Early sowing is more important in low rainfall areas
- Delayed sowing can assist weed control in some high rainfall areas and helps avoid poor pod set from excessive plant height, lodging and biomass production
- Match variety choice to time of sowing.

Sowing time is one of several factors that can help influence the risk of frost damage to lupin and other crops in the rotation.

Early lupin sowing is typically the most successful across most areas of the southern region, but this depends on achieving good weed control and crop root nodulation.

Lupin crops tend to perform best when sown into a moist seedbed to ensure a good and even establishment and nodulation.

There are three typical sowing time options, each with associated positive and negative outcomes, as outlined in Tables 2-4. With some planning, the negatives can be remediated.

In situations where growers need to dry sow, as highlighted in Table 2, it is advisable to consider sowing into paddocks with good stubble cover to avoid erosion.

Sowing into paddocks with low weed burdens can assist with poor simazine incorporation and increasing the seeding rate can compensate for poor establishment.

Success of wet sowing after the break, as shown in Table 3, will hinge on effective use of pre-seeding herbicides to ensure weeds that germinate with the crop remain under control.

Table 2: Pros and cons of dry sowing early in the season.<sup>4</sup>

Dry Sowing	
Positives	Negatives
Crop has longest growing season possible	Simazine incorporation is uneven when applied and tilled in dry soil. Simazine activity can be poor and weed burden high
Enables rapid establishment in warm soil	Germination on marginal moisture can lead to poor and uneven crop establishment
Logistically simple	Weeds grown through ineffective control are difficult and expensive to control
Brings forward time of sowing of other crops Improves machinery efficiency	Paddocks prone to wind/water erosion if ground cover is sparse

3 GRDC Grain Legume Handbook (2008), <u>www.grdc.com.au/grainlegumehandbook</u>

4 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cqi/viewcontent.cgi?article=1009&context=bulletins</u>





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 Table 3: Pros and cons of wet sowing.<sup>5</sup>

Wet sowing (on the break of 15 millimetres over two days)				
Positives	Negatives			
Promotes an even, competitive lupin crop emerging	Rapidly drying soil after the break can reduce establishment success			
Simazine applied prior to break will wash into soil, giving maximum weed control	Sowing naturally dries soil, reducing remaining soil moisture for germination and establishment			
Trifluralin effectiveness is increased when applied into moist soil on first rain				
Even crops assist effective post- emergent spray use				

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Table 4: Pros and cons of delayed sowing after the break into wet soil.

Delayed sowing	
Positives	Negatives
Allows full benefit of knockdown herbicides to take affect	Risk of long gap between break and follow up rains affecting crop success
Early germinating wild radish and annual ryegrass can be more easily controlled	Rate of yield loss from delayed sowing is greater in low rainfall zones
No simazine application prior to season break allows greater sowing flexibility	Slower germination and establishment due to cooler soil temperatures
Wet soil guarantees even competitive crop emergence	Potential delay to cereal program
Well suited to earlier maturing new	

Well suited to earlier maturing new varieties such as PBA Jurien<sup>(b)</sup>, PBA Bateman<sup>(b)</sup>, PBA Gunyidi<sup>(b)</sup> and PBA Barlock<sup>(b)</sup>

Optimum sowing dates for lupin crops in South Australia and Victoria can be loosely calculated on rainfall areas.

Rainfall zones below 350 mm of annual rainfall are suited to mid-April to early May sowing dates.  $^{\rm 6}$ 

Areas with 350 mm to 450 mm annual rainfall typically suit a mid-April to early May sowing date.  $^{7}$ 

But lupin crops on loam soils in both of these rainfall zones tend to require later sowing.

Rainfall zones from 450 mm to 550 mm of annual rainfall suit lupin crop sowing from mid to late May and zones with annual rainfall above 550 mm tend to suit late May to mid-June sowing of lupin.<sup>8</sup>

Yield losses can be significant if sowing is too late. Research has found there is potential to lose about 180 kg/ha for every one-week delay.<sup>9</sup>

Lupin crops require early sowing for seed to germinate in warmer temperatures, allowing early growth and nodulation. But sowing too early can result in issues with excessive growth, lodging and poor pod set.



<sup>5</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary. agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

<sup>6</sup> GRDC Grain Legume Handbook (2008), <u>www.grdc.com.au/grainlegumehandbook</u>

<sup>7</sup> GRDC Grain Legume Handbook (2008), <u>www.grdc.com.au/grainlegumehandbook</u>

<sup>8</sup> GRDC Grain Legume Handbook (2008), www.grdc.com.au/grainlegumehandbook

<sup>9</sup> GRDC Grain Legume Handbook (2008), <u>www.grdc.com.au/grainlegumehandbook</u>



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#### 2.4 Tillage systems

Tillage was historically used as a method of weed control in southern Australian lupin crops, but growers now tend to favour no-tillage stubble-retention systems.

Retaining about 20 percent or more of standing stubble has been found to help reduce the sandblasting of seedlings and the spread of Brown leaf spot, caused by the fungus *pleiochaeta*.<sup>10</sup> See more information in Chapter 7.

Reduced tillage can also be a useful management tool for this fungus.

*Pleiochaeta* spores are found close to the soil surface and will remain there with minimal soil disturbance. Seed placed below the spore layer tends to have a much lower exposure to infection.<sup>11</sup>

Minimum or no-tillage methods mean there is more reliance on herbicide weed control, or the use of wide sweep points to kill weed seedlings that have recently germinated.

This method has reduced soil disturbance in comparison to the historical preference of using full-cut seeding operations.

Management of rhizoctonia bare patch (caused by the fungal root pathogen *Rhizoctonia solani* AG8), an issue that cannot be controlled with rotating crops, is most severe in crops established using zero or minimum tillage.

The chances of this occurring can be reduced by sowing at a depth of 3-5 cm and cultivating 5-10 cm below this in a direct drilling operation.<sup>12</sup>

#### 2.5 Row spacing

Lupin crops tend not to respond to narrow row spacing as well as cereal crops, but there are many agronomic benefits of using narrow row spacing for this pulse.

Data from NSW has indicated lupin yield typically decrease as row spacing widens, especially for rows that are more than 50 cm apart.<sup>13</sup>

It is advised that if row spacing is increased, the seeding rate per row may need to be adjusted to maintain plant density.

Foliar fungicide spray and fertiliser application rates should also be adjusted.<sup>14</sup>

#### 2.6 Seeding rates

Narrow leafed lupin responds best to seeding rates that lead to establishment levels of 45 to 60 plants per square metre, which equates to a sowing rate of about 80 to 120 kg/ha of 75 percent germinable seed – depending on seed size and germinability.<sup>15</sup>

Higher-density sowing rates may be beneficial if sowing is delayed or the crop is weakened by low fertility or weed competition.

Newer varieties of narrow leafed lupin rely on pod set on the main stem, making higher density more important than for older varieties that produced more yield from branches.

- 12 GRDC Tips and Tactics Rhizoctonia (2015), https://grdc.com.au/uploads/documents/GRDC-FS-RhizoctoniaSW.pdf
- 13 Scott BJ, Martin P and Riethmuller GP, (2013), Row spacing of winter crops in broad scale agriculture in southern Australia: <u>https://www.csu.edu.au/research/grahamcentre/publications/monograph/row-spacing-monograph</u>
- 14 Pulse Australia, www.pulseaus.com.au/growing-pulses/publications/wide-rows-and-stubble-retention
- 15 GRDC Grain Legume Handbook (2008), <u>www.grdc.com.au/grainlegumehandbook</u>



<sup>10</sup> GRDC Grain Legume Handbook (2008), www.grdc.com.au/grainlegumehandbook

<sup>11</sup> CropPro Brown leaf spot/pleiochaeta root rot of lupins, <u>www.croppro.com.au/crop\_disease\_manual/ch09s02.php</u>


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Aside from yield, a high plant density lupin crop also has benefits of:

- » Less weed growth
- » Better crop competition with weeds
- » Less risk of Brown leaf spot and Cucumber mosaic virus (CMV) incidence/severity
- » Better compensation from root disease losses
- » More compensation if there is poor establishment (especially on water repellent sands)

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- » Lower susceptibility to wind erosion and sandblasting
- » Greater ease of harvesting.

(SOURCE: DPIRD)

Albus lupin does not require quite as high a plant density as narrow leafed lupin and – taking into account a larger seed for calculations – the suggested sowing rate is about 160 kg/ha.<sup>16</sup>

The formula for calculating sowing rate for lupin is:

Seeding rate (kg/ha) = Plant density (plants/m<sup>2</sup>) x 100 seed weight (grams) x 10 / Germination percentage<sup>17</sup>

# 2.7 Sowing depth

Lupin seed should not be sown too deep, but this depends on soil type. Shallow sowing can be used on some harder setting, heavier soils – but there may be risks when there is dry start to the season or there is a 'false break'.<sup>18</sup>

The optimum depth is from 1 - 3 cm and typically not deeper than 5 cm, as lupin is the least tolerant pulse crop to deep sowing<sup>19</sup>

Direct drilling seed is a best practice technique in the southern region.

Sowing depth of lupin can affect the incidence and severity of root diseases. Very shallow sowing tends to increase risks of *pleiochaeta* root rot affecting crops.

Deeper sowing can reduce the risk of this fungus affecting crops, but increases risks of hypocotyl rot.

Best yield results and root disease management tends to occur if seed is sown into a furrow at depth, placing the seed below the concentrated *pleiochaeta* spore layer, but not deeper than 5 cm.



<sup>16</sup> GRDC Grain Legume Handbook (2008), <u>www.grdc.com.au/grainlegumehandbook</u>

<sup>17</sup> Pulse Australia, www.pulseaus.com.au/storage/app/media/crops/2007\_Lupins-SA-Vic.pdf

<sup>18</sup> GRDC Grain Legume Handbook (2008), www.grdc.com.au/grainlegumehandbook

<sup>19</sup> GRDC Grain Legume Handbook (2008), www.grdc.com.au/grainlegumehandbook



# i) MORE INFORMATION

NSW Department of Primary Industries 'Lupin Growth and Development Guide': <u>http://www. dpi.nsw.gov.au/\_\_\_data/assets/</u> pdf\_file/0006/516183/Procrop-lupingrowth-and-development.pdf

Office of the Gene Technology Regulator 'The Biology of Lupinus L': http://www.ogtr.gov.au/internet/ ogtr/publishing.nsf/Content/ biologylupin2013-toc/\$FILE/ biologylupin2013-2.pdf

DPIRD 'Narrow Leafed Lupins with Restricted Branching': <u>http://aob.</u> <u>oxfordjournals.org/content/85/1/29.</u> <u>full.pdf+html</u>

# Plant growth (phenology) and development

# 3.1 Overview

Lupin plant growth and development are overlapping and complex.

Growth refers to the increase in size and number of leaves, stems and roots – which produce biomass. Fuelled by photosynthesis, this is directly related to water use and light interception.

Development is the process by which the plant moves from one growth stage to the next. Rate and timing depend on variety, photoperiod and temperature.

Correct identification of lupin plant growth stage enables effective crop management, especially for herbicide and pesticide applications and timing of harvest.

A growth scale is used to describe each developmental stage of the lupin plant and this is similar to the Zadoks Growth Scale for wheat.

The lupin growth scale covers six stages, starting with germination and finishing with seed ripening, and is sub-divided into 10 units per stage.

Some of the growth stages overlap during the plant's evolution, as can be seen in Table 1, but the stages are recognised as separate in plant development.<sup>1</sup>

Table 1: Lupin growth stages and numeral system.<sup>2</sup>

STAGE	DECIMAL SCORE
GERMINATION AND SEEDLING EMERGENCE	0
Dry seed	0.0
Start of imbibition (water absorption)	0.1
Radicle (root) protruding through the testa (seed coat)	0.3
Radicle 5 mm long (germination)	0.5
Hypocotyl protruding through the seed coat	0.7
Part of the seedling protruding through the soil	0.9
LEAF EMERGENCE	1
First pair of leaves protruding beyond upright cotyledons	1.0
1 leaf emerged from bud	1.1
2 leaves emerged from bud	1.2
3 leaves emerged from bud	1.3
4 leaves emerged from bud	1.4
5 leaves emerged from bud	1.5
7 leaves emerged from bud	1.7
10 leaves emerged from bud	1.10

Walker, J, Hertel, K, Parker, P, Edwards, J (2010) Lupin Growth and Development, Industry and Investment NSW, <u>http://www.dpi.nsw.gov.</u> au/\_\_\_data/assets/pdf\_file/0006/516183/Procrop-lupin-growth-and-development.pdf





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**DECIMAL SCORE** STAGE STEM ELONGATION 2 Little separation between bases of leaves 2.1 2.3 Bases of some basal leaves clearly separated 2.5 Bases of several leaves clearly separated from each other Flower spike (inflorescence) bud clearly visible 2.7 Flower spike bud clearly separated from the base of the 2.9 highest leaf FLOWERING 3 Bracts completely hiding corolla 3.0 Pointed bud stage 3.1 3.2 Hooded bud stage Diverging standard petal stage (anthesis) 3.3 Open flower stage 3.4 Coloured corolla stage 3.5 Senescent corolla stage 3.7 3.8 Floret abscised Pod set 3.9 POD RIPENING 4 Young green pod. No septa between seeds, seeds abutting 4.0 Seeds separated 4.1 Green pod, septa between seeds, slight bulging of walls, 4.2 seeds filling 50% of the space between the septa 4.3 Seeds filling 75% of the space between the septa 4.4 Green pod, clear seed bulges in pod walls, seeds filling all space between septa Green pod, septa split 4.5 Pod turning khaki-coloured 4.7 Pod pale reddish-brown and wrinkled 4.9 5 SEED RIPENING 5.0 Seed small, dark green with watery contents Seed medium, dark green with watery contents 5.1 Seed large, dark green with watery contents 5.2 Seed large and soft, light green coat, no watery contents, 5.4 green cotyledons Seed light green to pale greyish-blue coat, green cotyledons 5.5 Green to yellow cotyledons 5.6 Pale fawn coat, yellow to golden orange cotyledons 5.7 (physiological maturity) Seed hard but dentable, mottling of pale fawn coat 5.8 5.9 Seeds hard and harvest ripe





The plant, shown in Figure 1, is formed by leaves, flower spikes, branches, stem, roots, pods and seeds.

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(SOURCE: DPIRD)

Historically, lupin maturity categories have fitted into early, mid and late flowering.

But early flowering varieties now make up the bulk of plantings across the southern region and have no vernalisation (cold period) requirement before flowering.

If sown before mid-April, these varieties can start flowering in the cold and frosty conditions experienced during the winter growing period across southern Australia. Mid and late flowering varieties will often flower after typical cold and frosty periods. In some warmer, more northern, environments, late types may flower during periods of heat stress, which can affect yield.

Older narrow leafed lupin varieties, such as Wonga, will branch and flower as long as the season permits. These will produce most grain yield in the primary and first lateral pod set stages.

Newer, restricted branching types, such as PBA Bateman<sup> $\phi$ </sup>, PBA Jurien<sup> $\phi$ </sup>, PBA Barlock<sup> $\phi$ </sup>, Mandelup<sup> $\phi$ </sup> and PBA Gunyidi<sup> $\phi$ </sup>, are limited in branching habits.

Australian lupin breeding advances have led to the development of these types of varieties with less branching and more pods on the primary stem.

This has been in response to key productivity limitations of excessive and indeterminate vegetative growth and branching habits of traditional varieties, especially in narrow leafed lupin.





# leaf 2 leaf 1 stipule cotyledon soil surface white hypocotyl = hypocotyl depth of sowing first order lateral root

## 3.2 Germination and seedling emergence

**Figure 2:** Diagram of narrow leafed lupin seedling to indicate the positions of various parts

(SOURCE: Dracup, M. Kirby, E.J.M (1996) University of Western Australia, Lupin: Development Guide, trove.nla.gov.au/work/21902398)

Germination includes the three phases of water absorption, activation and visible germination and can take from five to 15 days.

The length of the phase depends on soil temperature, moisture and sowing depth, but is not determined by variety.

This growth stage begins when seed water content reaches about 60 percent of the seed weight.

Once germinated, the seed has the ability to grow in very dry soils and will not stop growing during moisture stress.

The swollen seed produces hormones and this engages enzymes and metabolism activity needed for starch to be broken into sugars for growth.

It is after this occurs that the radicle (growing plant embryo) ruptures the seedcoat (testa) of the seed and forms the anchor in the soil.

The roots form as a taproot system and then lateral roots grow out to form the secondary root system.

The root system size and pattern changes between species and the nodules containing the important rhizobia bacteria to fix nitrogen (N) in the soil form on this root system.

The hypocotyl, which is the long and white stem, simultaneously grows towards the surface.







# 3.3 Leaf emergence



Figure 3: Lupin at early stages of development.

(SOURCE: GRDC)

This is known as the epigeal seedling stage, where cotyledons emerge and expand above the ground.

The first leaf will grow from the centre of the cotyledons and, at the same time, root formation continues.

The leaves are formed as a palmate structure, with leaflets coming from a central point.

Narrow leafed lupin has narrow pointed leaves, which increase in number towards the top of the plant.

As shown in Figure 4, initially there are five leaflets per leaf and – towards the top of the plant – there can typically be between nine and 12.

The plant is heliotropic, facing the sunlight during the day. This process occurs until flowering begins.

A crop is said to be established when 50 percent of seeds have germinated and emerged and are developing with strong seedling vigour.

Crop germination, emergence and establishment can be affected by several factors, including moisture, temperature, soil crusting and seed quality.





(SOURCE: Dracup, M. Kirby, E.J.M (1996) University of Western Australia, Lupin: Development Guide, trove.nla.gov.au/work/21902398)







# 3.4 Stem elongation and branching



**Figure 5:** The lupin plant has a branching habit and each branch has its own flower spike.

(SOURCE: GRDC)



#### **Figure 6:** Branching in lupin plants occurs in stages illustrated in this diagram

(SOURCE: Dracup, M. Kirby, E.J.M (1996) University of Western Australia, Lupin: Development Guide, trove.nla.gov.au/work/21902398)

This stage occurs during the vegetative and reproductive phases of growth.

If the plant has access to adequate moisture, nutrients and sunlight, the branches and stem grow new lateral branches with flower spikes through to the reproductive phase.

The stem develops first and then each branch has its own flower spike, on which pods tend to mature at the same time.

Stem elongation is affected by accumulated temperature. This means that in the vegetative phases in winter, stem growth can be slow.





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Stem growth occurs as the internodes of the stem develop. This can be at a rate of 0.1-0.2 millimetres per growing degree day (GDD), which is a measure of heat accumulation used to predict plant and pest development rates.

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The main stem reaches its maximum length at about 1050 GDD.

Each variety will vary, with early flowering varieties having fewer nodes than later flowering varieties.

Nodules containing the N fixing bacteria (*Bradyrhizobium lupini*) are mainly formed on the top five to 10 centimetres of the taproot and first appear three to four weeks after germination.

# 3.5 Flowering



**Figure 7:** Crop of flowering narrow leafed lupin with white flower heads standing above a lush green crop.

(SOURCE: GRDC)



Figure 8: Flower development of lupin plants.

(SOURCE: Dracup, M. Kirby, E.J.M (1996) University of Western Australia, Lupin: Development Guide, trove.nla.gov.au/work/21902398)





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Typically, flowers form on the upper branches and these produce most of the lupin plant's yield.

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The flowering forms part of the reproductive development of the plant that starts after the main stem stops forming leaves. Flowers begin to grow over several days to form a flower spike.

The flower spike forms at the end of each branch and consists of several individual flowers (typically five-20).

The flowers have five petals and will flower for about 10-14 days. The plant as a whole will typically have flowers for four to eight weeks.

Flowering occurs along the whole length of the flower spike, from the base to the end of the stem.

The pollination and fertilisation stages of the flower must occur for pod setting and ripening. Narrow leafed lupin plants are self-pollinating and little cross-pollination is able to occur via insects. Varieties remain pure through this mechanism and insects do not increase pod development or yield.

The albus lupin has a similar pollination process, but cross-pollination can occur more readily.

Branch growth is very sensitive to moisture and temperature stress, so earlier sowing and flowering typically enables production of more branches.

The newer varieties, such as PBA Bateman<sup> $\phi$ </sup>, PBA Jurien<sup> $\phi$ </sup>, PBA Barlock<sup> $\phi$ </sup> and Mandelup<sup> $\phi$ </sup>, carry a high proportion of yield on the main stem relative to other varieties, which is an additional advantage.

These varieties can produce high yields without relying heavily on late maturing lateral branches, which also reduces the need for very early sowing.

Varieties such as Wonga rely more on the lateral branches for yield. This variety performs better at high and medium rainfall locations where the season length is long and early sowing is not as critical to ensure that seed in lateral pods will fill.

# 3.6 Pod ripening



**Figure 9:** Lupin pod walls harden close to the stem and keep the pod attached to the flower spike.

(SOURCE: GRDC)





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Figure 10: Pod and seed development, note the dates are typical for conditions in WA. (SOURCE: Dracup, M. Kirby, E.J.M (1996) University of Western Australia, Lupin: Development Guide, <u>trove.nla.gov.au/work/21902398</u>)

Pod formation occurs as a result of a fertilised flower ovary. Not all fertilised flowers will set pods and these can be identified by a stalk changing from green to yellow before being shed.

Newer lupin varieties are bred to have more pods than older varieties. But it can be common for a high number of flowers to be shed as a result of environmental factors, such as moisture stress and high temperatures.

If a fertilised flower ovary is to create a pod, the pod wall needs to harden close to the stem and keep it attached to the flower spike (otherwise the pod may abort).

A pod that reaches 8-10 mm is considered to be set and unlikely to fail. Walls will continue to thicken before seeds develop and these walls then provide nutrients for developing seeds.

During the early stages of pod development, there is strong competition for carbohydrates and nutrients elsewhere in the plant, which influences successful pod set. Colour changes of the pod (from green, through to khaki to light brown) and the developing cotyledons in the seed (from green to yellow) are useful indicators of the physiological stage of maturation.

Breeding advances in lupin have addressed previous problems with pod shattering during this phase of plant growth and harvest. PBA Bateman<sup>¢</sup>, PBA Jurien<sup>¢</sup>, PBA Barlock<sup>¢</sup> and PBA Gunyidi<sup>¢</sup> are some of the varieties benefitting from improvements in this trait, having resistance to pod shatter.





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# 3.7 Seed ripening

Seeds expand as they develop, taking on protein, carbohydrates and nutrients when the pods have reached full length and thickness.

Most pods develop five to six seeds over a period of 38 to 72 days. Seeds at the top of the plant's canopy tend to contain more oil than seeds formed on the main stem.

Seed maturity is reached when the seeds complete the accumulation of nutrients from the pod, there is no functioning connection to the plant and the maximum dry weight is achieved. Leaves on the main stem and lateral branches die off. From here, the seed, which can have a 62 percent moisture content reading at this stage, will typically continue to dry out to 13-14 percent moisture.

Total plant maturity is reached when more than 90 percent of the pods on the highest branches have reached maturity.

## 3.8 Lupin breeding advances

Aside from ornamental varieties, Australia is recognised as a world leader in lupin production due to a coordinated breeding and agronomic research effort, linked to an innovative farming community.

Weed management, herbicide tolerance, anthracnose resistance and yield reliability are the biggest agronomic issues being addressed by national lupin breeders to continue improving the productivity of this crop.

The Department of Primary Industries and Regional Development (DPIRD) – formerly Department of Agriculture and Food Western Australia (DAFWA) – was the national breeding centre for lupin crop development for 45 years and consistently released varieties for higher production and crop legume rotation benefits.

Initially, DPIRD's program focused on early flowering and resistance to Grey leaf spot, which threatened the industry in the 1970s. In more recent years, breeders have been working on improving adaptation, yield potential and resistance to other diseases.<sup>3</sup> Eastern States-based breeding efforts focused on higher rainfall and colder climate adaptation for lupin and late-season variety types.

This research led to the development and release of varieties with resistance to phomopsis, which can cause lupinosis in grazing animals, in 1988 and anthracnose in 1996.

DPIRD then increased its emphasis on breeding for better herbicide tolerance and grain quality.

At the same time, there was development of narrow leafed varieties with less (or restricted) branching to reduce excessive plant growth and boost pod set and pod seed-fill.

Restricting branching curbs the competing demands of vegetative and reproductive growth in the plant, which often occurs when growing conditions are deteriorating in southern Australia.

Researchers in the late 1990s started selecting for restricted branching in narrow leafed lupin and this led to germplasm being included in national breeding programs for the development of current varieties with these traits.<sup>4</sup>

The GRDC and DPIRD announced in 2016 that Australian Grain Technologies (AGT) will take forward Australia's lupin breeding program.

AGT will be examining how to best increase the value of lupin in Australian farming systems through improved yield, disease resistance, broader adaptation, herbicide tolerance and seed quality.<sup>5</sup>

- 3 White, P, French, B, McLarty, A (2008) Producing Lupins. Department of Agriculture and Food WA Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cqi/viewcontent.cgi?article=1009&context=bulletins</u>
- 4 Dracup, M, Thompson, B (2000) Narrow Leafed Lupins with Restricted Branching, DAFWA, CLIMA, <u>http://aob.oxfordjournals.org/content/85/1/29.full.pdf+html</u>
- 5 Watt, S (2016) AGT Brings lupins into its fold, GRDC Ground Cover magazine, <u>https://qrdc.com.au/Media-Centre/Ground-Cover/Ground-Cover/Isue-122-May-Jun-2016/AGT-brings-lupins-into-its-fold</u>





# i) MORE INFORMATION

GRDC 'Fact Sheet – Better Fertiliser Decisions for Crop Nutrition': https://grdc.com.au/GRDC-FS-BFDCN

GRDC 'Fact Sheet – Soil Testing for Crop Nutrition – Southern Region': https://grdc.com.au/Resources/ Factsheets/2014/01/Soil-testing-forcrop-nutrition-South

Better Fertiliser Decisions for Cropping Systems in Australia: www.bfdc.com.au

DPIRD 'MyCrop Lupin Diagnostic Tool': <u>https://www.agric.wa.gov.au/</u> <u>lupin-diagnostic-tool</u>

GRDC Grains Legume Handbook: www.grdc.com.au/Resources/ Publications/2008/03/2008-Grains-Legume-Handbook

# **Nutrition and fertiliser**

# 4.1 Overview

- Use soil/plant tissue tests or paddock history to determine fertiliser use and rates
- Deep soil testing to 30 centimetres is valuable for phosphorus (P) and potassium (K)
- Drill phosphate at seeding but beware of toxicity to seed or inoculum if either high rates are drilled or if the seeding row is narrow
- On some soils, banding phosphate below the seed can increase yields
- If needed, apply K within four weeks of sowing
- On potentially manganese (Mn)-deficient soils (mainly light sands) use Mn super, deep banded or a foliar Mn spray when first pods are 2.5 cm
- Monitor trace elements/micronutrients (especially if not applied within past 15 years).<sup>1</sup>

There is little new information available about lupin nutrition in southern Australia, but issues are similar to those for other pulses. Lupin crops are often grown on poorer soils or sands, which may require more attention to nutrition planning.

Lupin crops are typically responsive to phosphorus (P) and sulfur (S) and can require nitrogen (N) at sowing if following a 'N-hungry' crop, such as a cereal or canola.

Lupin is a legume able to fix its own N when inoculated with the correct rhizobia bacteria or nodulated from rhizobia in the soil.

On infertile soils in the southern cropping region, N deficiency can develop early in crop development and before enough N has been fixed.

In some cases, using starter N can improve early plant vigour in lupin crops.

Manganese (Mn) and P, at varying rates, are key nutrients that assist lupin crops reach potential yield.

The micronutrients, or trace elements, zinc (Zn) and S can be supplied as needed.

Deep banding of fertiliser, especially P, below the seed at sowing is typically preferred for lupin crops in the southern region. Alternatively, P and other fertilisers can be drilled pre-seeding.



GRDC (2013) Fact Sheet 'Better Fertiliser Decisions for Crop Nutrition', <u>www.grdc.com.au/GRDC-FS-BFDCN</u>



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# (i) MORE INFORMATION

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CSBP Soil and Analysis Laboratory: www.csbp-fertilisers.com.au/csbp-lab

EP Analysis: www.epanalysis.com.au

Nutrient Advantage Laboratory Services: <u>www.nutrientadvantage.</u> <u>com.au</u>

SGS Australia Ltd: www.sgs.com.au

GRDC 'Fact Sheet – Soil Testing for Crop Nutrition': <u>www.grdc.com.au/</u> <u>GRDC-FS-SoilTestingW</u>

CSIRO Australia 'Soil Fertility Manual': www.publish.csiro.au/pid/1998.htm

# 4.2 Soil tests

It is advisable to carry out pre-sowing soil tests to determine fertiliser use and application rates for lupin crops in the southern region.

A standard soil test report provides information about:

- » Soil type
- Organic carbon
- » Soil pH (measured in calcium chloride (CaCl<sub>2</sub>) or water)
- » Available P, K and S
- » Extractable micronutrients diethylenetriaminepentaacetic acid (DTPA), copper (Cu), Zn and Mn
- » Phosphorus buffering index (PBI)
- » Cation exchange capacity (CEC)
- » Aluminium (Al) level
- » Soil salinity: electrical conductivity (EC) and salt level (percent of Na)

Diffuse Gradient Technology Phosphorus (DGT-P) is a relatively new test method being assessed for use with Australian soils. It mimics the action of the plant roots in accessing available P. For more information go to: <u>http://soilquality.org.au/soil\_tests/dgt-phosphorous-0-10cm</u>

In southern Australia, Mn deficiency can be difficult to correct with solid fertiliser, particularly on calcareous soils where Mn fertiliser is rapidly immobilised. Foliar Mn applied during podding may therefore be required.

Similarly, Zn deficiency is a concern in many parts of southern Australia and is known to severely affect legume production.

The majority of soils suited to growing lupin crops in the southern cropping region also tend to have very low natural P levels.

When planning soil nutrition strategies, decisions are best made with key objectives in mind, particularly in terms of fertiliser rate selection. This is illustrated in Figure 1, which outlines the four 'Rights' of plant nutrition.<sup>2</sup>



<sup>2</sup> GRDC (2013) Fact Sheet 'Better Fertiliser Decisions for Crop Nutrition', <u>www.grdc.com.au/GRDC-FS-BFDCN</u>



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**Figure 1:** The Four 'Rights' of 4R Plant Nutrition: examples of the scientific principles behind crop nutrition and how they may translate into practical decisions.<sup>3</sup>

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	The 4Rs			
	Source	Rate	Time	Place
Examples of scientific principles	<ul> <li>Ensure balanced supply of nutrients</li> <li>Product suits soil properties (for example, choice of MAP or DAP)</li> </ul>	<ul> <li>Assess nutrient supply (for example, quantity of N or P in a fertiliser product or soil ameliorant) from all sources</li> <li>Assess plant demand (how much nutrient the crop requires based on target yield)</li> </ul>	<ul> <li>Assess dynamics of crop uptake and soil supply (for example, N is frequently applied in- crop based on demand, but current knowledge shows that P must be applied up front)</li> <li>Determine timing of loss risk (for example de-nitrification, volatilisation, leaching)</li> </ul>	<ul> <li>Recognise crop rooting patterns</li> <li>Manage spatial variability</li> <li>Plant access to applied nutrient</li> <li>Nutrient toxicities</li> <li>Crop choice</li> </ul>
Examples of practical choices	<ul><li>Commercial fertiliser</li><li>Livestock manure</li><li>Compost</li><li>Crop residue</li></ul>	<ul><li>Test soils for nutrients</li><li>Calculate economics</li><li>Balance cropremoval</li></ul>	<ul><li> Pre-plant</li><li> At planting</li><li> At flowering</li><li> At fruiting</li></ul>	<ul> <li>Broadcast</li> <li>Band/drill/inject</li> <li>Variable-rate application</li> <li>Percentage seed bed utilisation</li> </ul>

Soil test data from the National Land and Water Resources Audit (NLWRA) shows nutrient status of soils in southern Australia varies considerably, with big areas likely to be responsive to the application of P, K, S, and lime.<sup>4</sup>

Data collated by Incitec Pivot (soil test data, 2010, for SA and Victoria) found 50 percent of soils that year had a pH below 5, 40 percent of soils were low in K and S and soil and tissue tests showed micronutrient deficiencies of 20 percent for Cu and 10 percent for Zn.<sup>5</sup>



<sup>3</sup> GRDC (2013) Fact Sheet 'Better Fertiliser Decisions for Crop Nutrition', <u>www.grdc.com.au/GRDC-FS-BFDCN</u>

<sup>4</sup> National Land and Water Resources Audit (2008) The National Land and Water Resources Audit Final Report: 2002-2008, <u>http://wa.gov.au/products/pn22042</u>

<sup>5</sup> Christy, B, Riffkin, P, Clough, A, Norton, R, Stott, K, O'Leary, G (2015) Crop Yield Potential Limited by Nutrient Status in the High Rainfall Zone of Southern Australia, <u>http://www.agronomy2015.com.au/papers/agronomy2015final00198.pdf</u>





# 4.3 Diagnosing nutrient deficiencies

Figure 2: Common symptoms of nutrient deficiencies in narrow leafed lupin.

	LOCATION											
SYMPTOM		OLD L	EAVES	;	MIDDLE TO NEW LEAVES TEL					TERN SHC	1INAL DOTS	
Chlorosis												
Complete	*	-	-	-	-	-	*	-	-	*	-	-
Mottled	-	-	*	-	_	-	*	-	-	-	-	-
Margins	-	-	-	-	-	-	-	-	*	-	-	-
Cotyledons	*	*	-	-	-	-	-	-	-	-	-	-
Necrosis												
Complete	-	*	-	-	-	-	-	-	-	-	-	-
Distinct areas	-	-	-	*	-	-	-	*	-	-	-	-
Margins	-	-	-	-	*	-	-	-	*	*	-	-
Tips	-	*	*	-	-	*	-	-	*	*	*	*
Pigmentation within nec	rotic or	chloro	tic area	as							•	
Brown	-	-	-	*	*	-	-	*	*	*	-	-
Red	-	-	-	*	*	-	-	-	-	-	-	-
Purple	_	_	-	-	-	-	-	-	*	-	_	-
White	-	-	-	-	-	*	-	-	-	*	-	-
Malformation of leaflets												
Curled or twisted	-	*	-	-	*	-	-	-	-	-	-	-
Needle-like	-	-	-	-	*	*	*	-	-	-	-	*
Bent & disorientated	_	-	-	-	-	-	-	*	-	-	*	*
Water-stressed	_	*	-	-	-	-	-	-	-	-	-	-
Water-soaked	_	_	_	-	-	_	-	_	*	-	*	-
Malformation of leaves										•		
Umbrella formation	_	-	-	-	-	-	-	-	- 1	-	_	*
Claw formation	_	-	-	-	*	-	-	_	*	-	*	-
Rosettina	_	_	_	-	-	*	*	*	_	_	*	-
Leaf fall	_	-	*	_	*	-	-	-	-	-	-	-
Leaf & petiole fall	-	*	-	-	-	-	-	-	-	-	-	-
Petiole collapse	-	_	-	-	-	-	-	-	-	-	-	*
Root distortion	-	-	-	-	-	-	-	-	-	-	*	*
	N	Р	к	Mg	к	Mg	s	Zn	Mn	Fe	В	Ca
(SOURCE: DPIRD)				-		-						

#### Figure 3: Common symptoms of nutrient deficiencies in albus lupin.

	LOCATION										
SYMPTOM	OI LEA	LD VES	MIDDLE TO NEW LEAVES				TERMINAL SHOOTS				
Chlorosis											
Complete	*	*	*	-	*	-	-	*	-	-	-
Mottled	-	*	-	-	-	-	*	*	-	-	-
Interveinal	-	-	*	*	-	*	*	-	-	-	-
Intraveinal	*	-	-	-	-	-	-	-	-	-	-
On margins	-	-	*	-	-	-	-	-	-	-	-
Necrosis											
Complete	-	*	-	-	-	-	-	-	-	-	-
Distinct areas	-	-	*	-	*	*	-	-	-	-	-
Margins	-	-	-	*	-	-	*	-	-	-	-
Tips	-	-	-	*	-	-	-	-	*	*	*
Pigmentation within necrotic	or chic	orotic a	reas								
Green	-	*	-	-	-	-	-	-	-	-	-
Brown	-	*	*	-	*	-	*	*	-	-	-
Red	-	-	-	-	-	*	-	-	-	-	-
Bronze	-	-	-	*	-	*	*	-	-	-	-
Malformation of leaflets											
Miniaturised	-	-	*	-	-	-	-	-	-	-	-
Boat-like	-	-	-	-	-	-	*	*	*	-	-
Spike-like	-	-	*	-	-	-	-	-	-	-	-
Water-soaked	-	-	-	-	-	-	-	-	-	*	-
Malformation of leaves											
Umbrella formation	-	-	*	*	-	*	-	-	-	*	-
Claw formation	-	-	-	-	-	-	*	*	-	-	-
Star formation	-	-	-	*	-	-	-	-	*	-	-
Rosetting	-	-	-	-	-	*	-	-	-	*	-
-											
Leaf fall		*	-	-	-	-	_	-	-	-	-
Petiole collapse	-	-	-	-	_	-		-	-	-	*
Root distortion		-	-	-	-	-	-	*	-	*	*
	N	Р	K	Ma	S	Zn	Mn	Fe	Cu	B	Ca

(SOURCE: DPIRD)





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Visual symptoms of any nutrient deficiency in lupin crops can appear similar to those seen in other pulses or those caused by damage from herbicides, insects, disease or adverse environmental conditions, such as moisture stress, soil constraints or extreme temperatures.

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It should also be noted that considerable yield loss can occur without the appearance of any visual symptoms in-crop. This means it is advisable to confirm diagnosis of any suspected nutrient deficiencies in lupin using plant tissue testing.

Researchers in Western Australia have developed guidelines for assessing a range of potential nutrient deficiencies in narrow leafed and albus lupin crops and these are outlined in Figures 1 and  $2.^{6}$ 

More information about diagnosing nutrient deficiencies is also available on the Department of Primary Industries and Regional Development (DPIRD)-GRDC MyCrop hub at: <u>https://www.agric.wa.gov.au/mycrop</u>

Tips for identifying nutrient deficiencies in lupin crops in the southern region include:

- Know what a healthy plant looks like in order to recognise symptoms of distress
- Determine what the affected areas of the crop look like (i.e. are they discoloured, dead, wilted or stunted?)
- Identify the pattern of symptoms in the field (i.e. patches, scattered plants, crop perimeters)
- Assess affected areas in relation to soil type (i.e. pH, colour, texture) or elevation
- Check individual plants for more detailed symptoms (i.e. stunting, wilting).

Considerations when diagnosing nutrient disorders in pulse crops are outlined in Figure 4.



#### Figure 4: Flow chart for the identification of deficiency symptoms.

(SOURCE: T Reddy, G Reddi (1997) Mineral nutrition, manures and fertilizers. In Principles of Agronomy. pp. 204-256. Kalyani Publishers, Ludhiana, India)

Visual symptoms may be caused by damage from herbicides, insects and/ or pathogens

Damage may also be from physiological disorders arising from adverse environmental effects, such as salinity, drought, cold, heat or high temperature stresses and symptoms can be indistinguishable from nutrient deficiency - although it should be obvious if environmental conditions are limiting (such as moisture stress)

6 Snowball, K. and Robson, A.D. University of Western Australia (1986) Symptoms of nutrient deficiencies, <u>http://trove.nla.gov.au/</u> work/18831182?g&versionId=22106141





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Factors that influence both nodulation and nitrogen fixation can result in symptoms of N deficiency

There can be differences between varieties in the manifestation of symptoms

Visual symptoms in one pulse do not necessarily mean that it is the same in other pulses.

It should be noted that if more than one nutrient deficiency is present in a lupin crop, typical visual symptoms may not occur. If two nutrients are simultaneously deficient, symptoms may differ from the deficiency symptoms of the individual nutrients.

Micronutrients are often used by plants to process other nutrients, or work together with other nutrients, so a deficiency of one may look like deficiency of another.

# 4.4 Plant tissue testing

Plant tissue tests can be used to confirm if crops are deficient in nutrients, particularly trace elements.

Tissue testing reflects what the plants can take up from the soil at the time of sampling.

These tests can provide accurate diagnosis of nutrient deficiencies, particularly where it is difficult to rely on visual symptoms in the paddock.

In some cases, plants might not show obvious signs of a deficiency even though crop growth may be restricted.

A stem test for Mn is available at early flower budding to diagnose the likelihood of Mn deficiency during grain fill that can lead to 'split' seed or 'shrivelled' seed if not corrected.

Regular testing facilitates longer-term monitoring of crop growth and performance.

The most useful elements for plant tissue analysis in lupin crops include P, Mn, Cu, Zn and S.

Table 1 shows the elements (based on WA data) that can be provided for lupin crops in a standard plant tissue test report.

**Table 1:** Recommended minimum plant nutrient levels for a range of pulse crops, during vegetative stages (seedling to budding).<sup>7</sup>

Plant nutrient	Faba bean	Lupin	Field pea
Phosphorus (P) (%)	0.35 – 0.45	0.2 - 0.3	0.25 - 0.4
Nitrogen (N) (%)	4.0	4	-
Potassium (K) (%)	2.0 – 2.5	1.2 – 1.5	1.5 – 2.0
Sulphur (S) (%)	-	0.2 – 0.25	-
Magnesium (Mg) (%)	0.2	-	0.2
Calcium (Ca) (%)	0.6	-	0.6
Micronutrient (or trace elements)			
Manganese (Mn) mg/kg	20 – 25	17 – 20	20 – 30
Iron (Fe) ppm	-	-	-
Copper (Cu) mg/kg	>3.0	>1.2	>3.0
Zinc (Zn) ppm	>20 – 25	>12 - 14	20 – 30
Boron (B) mg/kg ppm	10	15	10

Young leaves are recommended for micro-nutrient testing.

7 DPIRD (2016) Monitor plant nutrition levels, https://www.agric.wa.gov.au/mycrop/monitor-plant-nutrition-levels

# i) MORE INFORMATION

GRDC '2016 Update Paper – Detecting and managing trace element deficiencies in crops': <u>https://grdc.com.au/</u> <u>Research-and-Development/</u> <u>GRDC-Update-Papers/2016/02/</u> <u>Detecting-and-managing-traceelement-deficiencies-in-crops</u>





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# 4.5 Fertiliser application methods

In SA and Victoria, the key soil nutrient considerations are N, P, K, Mn, molybdenum (Mo), S, Zn, iron (Fe) and cobalt (Co).

There are several methods of applying these nutrients to lupin crops, including:

- » Injection
- » Surface broadcast
- » Broadcast incorporated
- » Fertigation
- » Banded application
- » Foliar application
- » Sidedress
- » Topdress
- » Seed placement.

Some of the benefits and drawbacks of each method of fertiliser application are outlined in Table 2.

Table 2: Benefits and drawbacks of fertiliser application methods.8

Method	Advantages	Disadvantages		
Liquid Injection	Reduce losses through precise application of liquid nutrients	Slow, expensive (requires specialised equipment		
Surface broadcast – unincorporated or mixed only by seeding	Fast, economical	High nutrient losses, low uniformity, P efficiency is only one third to one quarter of banding		
Surface broadcast incorporated by prickle chain or harrows	Reduces losses compared to broadcast, improves plant uptake	Slow, non-uniform application, erosion risk, multiple applications		
Band application	High nutrient use efficiency, jump-starts early growth, many fields are deficient in P due to soil binding and cold temperatures -banding P makes it easier for plants to grow, it also slows $NH_4^+$ conversion to $NO_3^-$ (nitrification), reducing the risk of leaching.	Costly, slow, small risk of salt burn toxicity to seeds		
Foliar application	Rapid uptake if leaf area is large	Phytotoxicity, high expense, limited to small and/or repeated application		
Sidedressing	High nutrient use efficiency	Timing often falls during the wet and busy season, slow process		
Topdressing –	High nutrient use efficiency	Losses can occur		
post-sowing		Uneven application is possible		
Seed placement	Lower equipment costs, starter effect greater than just meeting nutrient requirements	Can be phytotoxic if too much fertiliser is applied, retro-fitting planters can be expensive, urea and DAP cannot be used		

As well as application method, the timing and amount of nutrients applied are important considerations.

8 Cornell University (2016) Northeast Region Certified Crop Adviser Study Resources, Competency Area 4: Nutrient sources, Analyses, Application Methods, <u>https://nrcca.cals.cornell.edu/nutrient/CA4/CA0434.php</u>







#### 4.6 Nitrogen (N)



Figure 5: Nitrogen deficiency can lead to nodule dysfunction in white and narrow leafed lupin crops and adding small amounts of N can be beneficial.

(SOURCE: Alan Robson)

Nitrogen influences almost all components of lupin crop growth. It is required for leaf and root growth, nodule formation and chlorophyll production.

The rate of leaf expansion is sensitive to early N levels and even temporary fluctuations in levels of available N can slow the rate of leaf emergence and reduce leaf size. A subsequent increase in the supply of N will not compensate for this loss.

Lupin is a legume and capable of fixing its own N via a symbiotic relationship with bacteria in nodules on its roots.

In the early stages of growth, fertiliser planted with the seed and nitrate-N mineralised from the soil supply the plant until N-fixation begins.

Early sowing and warm soil temperatures promote root growth and progress the start of N fixation.

Too much fertiliser or soil-based N tends to reduce or delay nodulation and slow down N fixation by the root nodules.

Short periods of waterlogging can also reduce nodulation and cause N deficiency.

Using ammonium-based fertiliser can reduce nodule formation and growth. Ammonium has a greater effect than nitrate.

Delaying or separating ammonium application typically increases nodule numbers by improving infection by Bradyrhizobium lupini bacteria, responsible for fixing atmospheric N.

Nitrogen fertilisers in small amounts (such as five to 15 kilograms of N per hectare) are typically not harmful to nodulation and can be beneficial by pushing out the early root growth to establish a stronger plant.9

Fertilisers containing lower levels of N, such as Mono-Ammonium Phosphate (MAP) or Granulock Z, can be used.

The use of starter N, such as Di Ammonium Phosphate (DAP), banded with the seed when sowing pulse crops, has the potential to reduce establishment and nodulation if higher rates are used.



White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins





# 4.7 Phosphorus (P)



**Figure 6:** Low phosphorus is shown on severely deficient plants, centre and right, that bend or become twisted before dying.

(SOURCE: A. Robson)

Phosphorus is an essential component of cell membranes and plant genetic material and in the energy storage and transfer system in plant cells.

Leaves of P deficient narrow leafed lupin plants frequently drop, after first beginning to die back from the tips.

Leaves of albus lupin that are deficient in P typically show yellow mottling before dying from the tips.



**Figure 7:** Symptoms of phosphorus deficiency in the paddock can include smaller plants with thinner stems and fewer lateral branches, as pictured left. (SOURCE: DPIRD)





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Phosphorus is mobile within plants and can be re-mobilised from leaves, roots and stems to the grain.

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In the southern region, it is recommended to drill or band P at seeding.

Banding of P below the seed can increase yields on some soils, particularly those with high P retention.

Experience indicates that placing fertiliser with the seed at sowing at levels higher than 15 to 20 kgP/ha can cause toxicity and reduce crop emergence. Damage tends to be greater in drier soils or where the seed furrrow is narrow (such as when using a disc slot).

Separating seed and fertiliser by banding P below the seed can reduce damage without reducing availability to the plant.

Soil P levels influence the rate of nodule growth, with higher P levels typically producing increased nodule growth.

Phosphorus required per tonne of expected lupin yield, by soil type and Colwell soil test for the top 10 cm soil (mg/kg) is illustrated in Table 3.

**Table 3:** Phosphorus required per tonne of expected lupin yield, by soil type and Colwell soil test for the top 10 cm soil  $(mg/kg)^{10}$ 

Colwell (mg/kg)	10-15	15-20	20-25	25-30	>30			
Rating	Low	Marginal	Adequate	Good	V. good			
	Units of P required per tonne of lupin yield expected by soil type and soil P level							
Calcareous Soil	7.5	4.5	3	3	3			
Non calcareous soil	6	3	3	3	3			

# 4.8 Potassium (K)



Figure 8: Potassium deficiency on albus lupin plants. (SOURCE: Alan Robson)



<sup>10</sup> Rural Directions, South Australia 2016.



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If soil tests indicate a deficiency for K, it is advised to apply this nutrient within four weeks of sowing. Excessive K fertiliser leaching can occur on very sandy soils if applied earlier than four weeks after sowing in high rainfall areas because roots are insufficiently developed to capture all of the K.

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Potassium chloride (Potash) can be toxic when drilled with the seed.

Potassium is used in many plant processes, including photosynthesis, sugar transport and enzyme activation. It is particularly important in regulating leaf stomata.

Plants that have adequate levels of K tend to be better able to tolerate drought and waterlogging than plants deficient in K.

Lupin crops take up less K than wheat and canola but use it more effectively.

Clay and loam soils have adequate amounts of K for plant growth. But sandy soils can be deficient in K.

High rates of hay or grain removal can result in K deficiency, but lupin roots can access nutrients at greater depth than cereals. Topdressed or banded K fertilisers can help to correct the deficiency.



**Figure 9:** In the paddock, low potassium can lead to smaller, thinner plants that are more susceptible to disease, as shown on right.

(SOURCE: DPIRD)







# 4.9 Sulfur (S)



**Figure 10:** Narrow leafed lupin plants showing sulfur deficiency symptoms of pale coloured leaves on right.

(SOURCE: Alan Robson)

Sulfur is needed by lupin plants for seed production and to form chlorophyll and protein. It also helps in nodule formation and is essential for N fixation.

Adequate S is required to maintain N efficiency and low soil S levels tend to result in poor N utilisation by lupin crops.

Leaf symptoms of S deficiency in lupin plants are generally not distinct enough to be detected in the paddock.

When S is deficient, protein synthesis is inhibited and plants become pale, with symptoms similar to those of N deficiency in legumes as shown in Figures 10 and 11.



**Figure 11:** As pictured right, low sulfur levels affect growth and colour simultaneously.

(SOURCE: A. Robson)





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A plant tissue test is the best way to confirm any suspicions of S deficiency.

Sulfur deficiency is frequently found in siliceous sand rises in low rainfall areas of SA and Victoria, where depth of sand is greater than 30 cm.

Sulfates, such as nitrates, leach readily in sands and it is recommended S levels are monitored, or a regular application of fertiliser containing S applied.

Single superphosphate contains about 10.5 percent S and there are a range of highanalysis fertiliser products available that contain high levels of S.

When these fertilisers are used, they can help maintain adequate S levels in soils for cropping.

Canola has a large requirement for S and ammonium sulfate and gypsum (calcium sulfate) are often used as extra sources of S in this phase of the rotation.

These products contain about 24 and 17 percent of S respectively.<sup>11</sup>

Sulfur applied as gypsum is less likely to leach, as it is less water soluble than other forms of sulfate.

Deficiencies of S will also tend to occur in crops grown on deeper sandy soils in higher rainfall areas when high analysis fertilisers containing negligible S, such as triple superphosphate (about 1.5 percent S) or DAP (about 1 percent S), have been used for several years.



**Figure 12:** Without addressing sulfur deficiencies in the paddock, new leaves and new growth can become very pale green and clumpy, as pictured. (SOURCE: DPIRD)









# 4.10 Manganese (Mn)



Figure 13: Manganese deficiency in narrow leafed lupin plants. (SOURCE: Alan Robson)

Manganese is needed for many metabolic processes in the lupin plant, including chlorophyll production.

It is relatively immobile and deficiency symptoms occur mostly during pod fill.

Research indicates adequate Mn levels in youngest fully open leaf (YOL) and main stem in legumes (including lupin) are about 20 mg/kg (identified through plant tissue testing). For these tests, about 20-30 lupin stems/test are required.<sup>12</sup>

On potentially deficient soils (mainly light sands), Mn can be applied as Mn super, deep banded under the seed, or as a foliar spray when first pods are 2.5 cm in length. A repeat application may be required to cover the third or fourth order lateral flowers and pods where there is an extended growing season.

Manganese deficiencies can result in split seed disorder in lupin crops later in the season which results in poor seed viability and germination. Shrivelled seed can result from a severe deficiency of Mn.



<sup>12</sup> Wilhelm, N, Davey, S (2016) Detecting and managing trace element deficiencies in crops, 2016 GRDC Grains Research Update paper, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Detecting-and-managing-trace-element-deficienciesin-crops



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**Figure 14:** Low Manganese can lead to split seed disorder, where seeds split through the seed coat and may be shrivelled.

(SOURCE: DPIRD)

Manganese deficiency can be prevented by applying Mn to the soil (direct drill with seed) or using a foliar spray when pods on the main stem are 2-3 cm long and the secondary stems have almost finished flowering. Mn sulfate is commonly used.<sup>13</sup>

Fertiliser applied to the soil has a good residual value, lasting for several years, whereas foliar sprays will supply Mn only to the crop to which it is applied.

Commercial superphosphates that contain Mn sulfate are available and have a range of Mn concentrations in the fertiliser.



**Figure 15:** Lupin plants with low manganese levels, on right without fertiliser treatment, tend to stay green with straggly growth as leaves drop and pods fill on unaffected plants, shown left, with fertiliser.

(SOURCE: CSBP)





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Applying 4 kg/ha of Mn sulfate in 75-100 Litres of water directly on to the foliage of lupin crops can be an effective method of controlling split seed disorder.<sup>14</sup>

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But foliar sprays sometimes fail and the development stage of the seed at the time of spraying is critical.

Manganese deficiency is of particular consideration for growing lupin crops on the calcareous soils of the Eyre and Yorke peninsulas, the upper to mid-south-east regions of SA and potentially on alkaline soils in the SA, VIC and southern NSW Mallee areas.

In some cases, Mn deficiency has been induced in paddocks that have been treated with clay to increase fertility and reduce water repellence.

# 4.11 Molybdenum (Mo)



**Figure 16:** Molybdenum deficiency (pictured right) in narrow leafed lupin crops can affect rhizobia ability to fix nitrogen.

(SOURCE: Alan Robson)

This trace element is essential for rhizobia to fix N and is part of the enzyme that converts nitrate-N (the form taken up from the soil) to nitrite-N (the form used by plants). It is also essential for N fixation.

Lupin crops are often grown in acid soils in parts of the southern region and these are commonly low in Mo.

Management of Mo deficiency in lupin crops includes:

- » Using seed with a known high level of Mo
- » Raising the pH of the soil
- » Coating the seed with Mo fertiliser
- » Using an in-crop compound fertiliser containing Mo
- » Applying Mo with herbicide.<sup>15</sup>

Proteoid roots can increase the availability of Mo in albus lupin.

Coating seed with Mo fertiliser is one way to supply Mo to deficient seeds.



<sup>14</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>

<sup>15</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cqi/viewcontent.cgi?article=1009&context=bulletins</u>



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But coating seeds with a solution of sodium Mo has resulted in nodulation problems in some areas, possibly due to the Mo salt killing the *Bradyrhizobium* bacteria in the inoculum. The molybdate solution (5-6 percent Mo) is also alkaline (pH 9-10), potentially causing a breakdown of the seed dressing used to control Brown leaf spot disease of lupin (*Pleiochaeta setosa*).<sup>16</sup>

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# 4.12 Zinc (Zn)



**Figure 17:** Zinc deficiency in lupin crops can cause irregular dark blotches on tips of older leaves.

(SOURCE: Alan Robson)

Zinc is involved in the enzyme systems of plants and is needed for protein synthesis, hormone production, carbohydrate metabolism and membrane stability.

It is taken up from the soil solution as water-soluble Zn and lupin plants have been shown to be less efficient than other winter crops at accessing this nutrient from the soil.

Across SA and VIC, lupin crops are grown mainly on sandy soils that are typically low in most nutrients, including Zn.

Zinc deficiency is common on the calcareous sands of the Eyre and Yorke peninsular areas.

Albus lupin is more sensitive than narrow leafed lupin to Zn deficiency.

Leaf symptoms of Zn deficiency are typically not distinct enough to be detected in the paddock.

Plants with mild Zn deficiency produce new leaves that are slightly paler than nondeficient plants.

Severe Zn deficiency causes irregular, dark brown blotches on the tips and margins of older leaves and the crown. It can also delay flowering.

Other symptoms are a reduction in stem length and increased branching of lateral roots.



<sup>16</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>





# 4.13 Iron (Fe)



**Figure 18:** Iron deficiency (shown on right) in lupin plants can affect nitrogen fixation.

(SOURCE: Alan Robson)

Iron is required by the lupin plant for effective N fixation, so the nodule initiation phase is the most sensitive to low soil Fe levels.

Plants with Fe deficiency produce bright yellow young leaves.

Iron deficiency is rare on acid soils. On alkaline and calcareous soils, narrow leafed lupin tends to be more sensitive than albus lupin to Fe deficiency.

Waterlogged alkaline soils can also induce a temporary deficiency that typically dissipates when the soil dries out.

Iron deficiency will typically occur in lupin crops grown on soils with a pH above 7.0 if the soil aeration is reduced slightly and temperatures are cold.

Lupin crops grown on fine-textured, alkaline soils that become saturated with water in winter will typically show bright yellowing of young leaves.







**Figure 19:** In the paddock, lupin crops with iron deficiency tend to have smaller, paler plants with chlorotic new leaves.

(SOURCE: Alan Robson)

Foliar application of Fe will reduce symptoms of deficiency and improve plant growth, but has not been shown to increase grain yields.<sup>17</sup>

The yield potential of lupin on alkaline soils tends to be lower than for most other grain legumes.

Lime-induced chlorosis symptoms are also a strong indicator in SA and Victoria of the presence of free lime in the soil. Crops in free lime often fail or are very unproductive. These symptoms and pH soil tests will show that sowing lupins in these areas should be avoided.

# 4.14 Cobalt (Co)

Cobalt is needed by rhizobia bacteria to fix N. Therefore, Co deficiency reduces the N concentrations in the lupin plant shoots.

Narrow leafed lupin is more sensitive than albus lupin to Co deficiency.

Seeds with low Co concentrations sown into soils deficient in Co tend to produce poorly nodulated lupin roots with ineffective nodules and the crop may become N deficient.



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<sup>17</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>







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**Figure 20:** Magnesium deficiency (shown centre and right) in narrow leafed lupin plants can be seen as lighter, pale leaves.

(SOURCE: Alan Robson)

As the central atom of the chlorophyll molecule, the main roles of Mg in the lupin plant are photosynthesis and P transport.

Magnesium accumulates in the seeds of plants that are rich in oil because the oil is accompanied by an accumulation of lecithin, a fat that contains P.

Therefore, the P content of a crop can occasionally be increased by adding a Mg fertiliser instead of a P fertiliser.

Magnesium also assists in P metabolism, plant respiration, protein synthesis and the activation of several enzyme systems in the plant.

When Mg deficiency symptoms first show in lupin, typically there has not yet been damage to the plant.

Plants grown without any Mg are a lighter green, with some mild interveinal yellowing appearing on new and old leaves.

The 'old-leaf' symptom is very specific to Mg deficiency, along with the presence of small bronze spots distributed randomly over the entire leaflet.

These spots expand only slightly and do not merge to form areas of necrosis. These old leaves slowly turn a dull greyish green.

The new-leaf symptom is vastly different, with the thin and spiky leaflets arranging into a cluster and the tips swiftly dying – but with little distortion such as curling or twisting. The whole plant finally turns a dull green colour.







# 4.16 Boron (B)



**Figure 21:** Boron deficiency in narrow leafed lupin crops is rare but can lead to abnormal lateral growth on plants.

(SOURCE: Alan Robson)

Boron deficiency is unlikely to be a major issue in lupin crops in the southern region. But, if diagnosed, foliar applications of fertilisers can act rapidly to minimise yield loss.

Timing and rate of application is important to avoid irreversible damage.

Soil application of B generally lasts longer than foliar B products, but can be leached from acidic, sandy soils.

There is no calibrated soil test for B deficiency in lupin. Soil testing may be useful on deep sands, but subsoil testing for B levels should also be conducted on duplex soils.<sup>18</sup>

In Australian trials, lupin has tended not to show significant shoot or grain yield responses to applied soil or foliar B fertiliser.

# 4.17 Calcium (Ca)

Calcium is necessary for growth and functioning of lupin root tips.

Calcium pectate is a component of the cell walls, increasing mechanical strength of the plant, and tends to be stored in the leaf. It also activates many plant enzyme systems and neutralises organic acids in the plant.

A large supply of Ca is needed for nodulation and N fixation by lupin and other legumes.

The roots of some legumes have a higher Ca demand during the stages of root infection by rhizoctonia hypocotyl rot (*Rhizoctonia solani*) than during plant growth.

The first sign of Ca deficiency in lupin plants tends to be a shortening of the lateral roots. Soon the tips of these laterals turn a brown colour, which extends some distance back from the tips.

Signs of Ca deficiency on plant tops soon appear. New leaves that are not fully expanded have the ends of leaflets remaining tightly closed, as though they are stuck together.

18 Anderson, G, Brennan, R, Bell, R, Chen, W (2015) Making better fertiliser decisions for cropping systems in Western Australia. Soil test – crop response relationships and critical soil test values and ranges, DAFWA Bulletin 4865, Murdoch University, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1042&context=bulletins</u>





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As seen in many other plant species suffering from Ca deficiency, petioles of new leaves bend and finally collapse, although the leaves may show no more than a few chlorotic areas.

Some bending of the main stem can occur, indicating the role of Ca in stem wall construction.

Young growth soon develops necrotic tipping of the unopened leaflets, followed by the collapsing of the petioles. Eventually, the new growing tip decays before any elongation of the petioles can occur and old and middle leaves become mottled and chlorotic, die and shed.

# 4.18 Nutrition benefits of lupin in the crop rotation

Incorporating lupin or other legumes into crop rotations in the southern region provides nutrition benefits to the whole farming system by increasing supply of organic/mineral N and reducing the need for N fertilisers.

Lupin crops require high levels of N for growth and most of this comes from the atmosphere through symbiotic N fixation with rhizobia.

After the lupin crop is harvested, a proportion of this N remains behind in paddocks as decaying roots, fallen leaves and stubble. Over time, this source of N becomes available to subsequent crops.

Typically, the higher the lupin biomass, the more organic/mineral N is left behind in the paddock because of an abundance of roots, branches and leaves.<sup>19</sup>

Organic N compounds must be converted to inorganic forms. This is carried out by soil microorganisms as they decompose soil organic matter and/or residues from previous lupin crops (and other legumes and pastures).

Peak N demand from crops can be four or five times the rate of N mineralisation, but N fixation and residual N remaining after a lupin crop are usually highly valuable to the system.

Research has found legume N can substantially reduce the need for fertiliser N inputs – often by up to 40-80 kgN/ha in SA – and lifts productivity of subsequent cereal and canola crops. On average, lupin crops across southern Australian soils have been shown to fix up to 20 kgN/ha per tonne of dry matter.<sup>20</sup>

# 4.19 Nitrogen budgets

The amount of N that will be fixed by a lupin (or other legume) crop and contribute to soil levels at the end of the growing season is determined by:

- » The amount of legume N accumulated over the growing season (measured in shoot dry matter (DM) production and percent N content)
- $\ast$  The proportion of the legume N derived from atmospheric  $\rm N_{2}$  (often abbreviated as percent Ndfa).

Total N fixed by lupins is typically calculated by adjusting the shoot measures of  $\rm N_2$  fixation to include an estimate of how much fixed N might also be associated with the nodulated roots using a 'root factor'.<sup>21</sup>

# i MORE INFORMATION

GRDC 'Fact Sheet – Nitrogen Fixation of Crop Legumes: Basic principles and practical management': https://grdc.com.au/Resources/ Factsheets/2014/07/Nitrogen-fixationof-crop-legumes-basic-principlesand-practical-management

GRDC 'Fact Sheet – Maximising Nitrogen Availability to Crops': <u>https://grdc.com.au/GRDC-FS-</u> <u>PlantAvailableNitrogen</u>

GRDC 'Fact Sheet – Break Crop Benefits – West': <u>http://grdc.com.au/</u> <u>Resources/Factsheets/2011/03/Break-</u> <u>Crop-Benefits-West</u>

GRDC 'Ground Cover Supplement – Flexible Farming' (June 2012): <u>http://gc-supplement.realviewdigital.</u> <u>com/?iid=66229&startpage=page</u> <u>0000015#folio=8</u>



<sup>19</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>

<sup>20</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>

<sup>21</sup> Peoples, M, Swan, T, Goward, L, Hunt, J, Hart, R, Hart, B (2015) Legume effects on available soil nitrogen and comparisons of estimates of the apparent mineralisation of legume nitrogen, CSIRO, Hart Bros Seeds, FarmLink Research, <u>http://www.agronomy2015.com.au/</u> papers/agronomy2015final00161.pdf



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For many lupin and pulse legumes, about one third of the plant N may be belowground in roots and nodules. In this case, a 'root factor' of 1.5 would be used. The equation is:

Total N fixed = (shoot N fixed) x root factor.

National research indicates brown manured (BM) crops and forage legumes generally provide higher net returns of fixed N to soils than grain crops. This is because high amounts of N are removed in the high-protein legume grain at harvest.

However, researchers found it was also clear from these data that different legume species had different potential for growth and  $N_2$  fixation regardless of eventual end-use.<sup>22</sup>

As shown in Table 4, a trial in NSW showed concentrations of soil mineral N were 18 or 34 kg N/ha higher under a lupin grain crop-wheat and lupin BM-wheat sequences, respectively, than for wheat-wheat in 2013 when another wheat crop was grown.<sup>23</sup>

**Table 4:** Concentrations of soil mineral N (0-1.6m) measured in autumn 2012 and 2013 following either wheat, canola and lupin grown for grain or brown manure (BM) at Junee, NSW in 2011, and calculations of the apparent net mineralisation of N from lupin residues.<sup>24</sup>

Crop grown in 2011	Soil mineral Nautumn 2012	Apparent mineralisation of legume N	Soil mineral Nautumn 2013	Apparent net mineralisation of legume N
	(kg N/ha)	(% 2011 residue)	(kg N/ha)	(% 2011 residue)
Lupin BM	169	32%	167	12%
Lupin	119	22%	151	10%
Wheat	77	-	133	-
Canola	76	-	115	-
LSD (P<0.05)	35		20	

This research showed about 19 kg of legume shoot N is commonly fixed per tonne of shoot DM produced by pulse crops.

Median estimates of percent Ndfa across 35 growers' crops indicated these crops were deriving about 70 per cent of N requirements from atmospheric  $N_2$  and fixing about 6 kg shoot N/t DM produced.

The researchers concluded that residual fixed N from BM crops or pure pasture legume swards was generally higher than net inputs of fixed N remaining after pulses.

This was mostly due to the export of large amounts of N in harvested grain.

They advised there is considerable evidence that the inclusion of legumes in cropping sequences results in higher available soil N for subsequent crops and this might be as much as 25-35 kg N/ha (on average) more mineral N than after wheat crops.<sup>25</sup>



<sup>22</sup> Peoples, M, Swan, T, Goward, L, Hunt, J, Hart, R, Hart, B (2015) Legume effects on available soil nitrogen and comparisons of estimates of the apparent mineralisation of legume nitrogen, CSIRO, Hart Bros Seeds, FarmLink Research, <u>http://www.agronomy2015.com.au/papers/agronomy2015final00161.pdf</u>

<sup>23</sup> Peoples, M, Swan, T, Goward, L, Hunt, J, Hart, R, Hart, B (2015) Legume effects on available soil nitrogen and comparisons of estimates of the apparent mineralisation of legume nitrogen, CSIRO, Hart Bros Seeds, FarmLink Research, <u>http://www.agronomy2015.com.au/</u> papers/agronomy2015final00161.pdf

<sup>24</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>

<sup>25</sup> Peoples, M, Swan, T, Goward, L, Hunt, J, Hart, R, Hart, B (2015) Legume effects on available soil nitrogen and comparisons of estimates of the apparent mineralisation of legume nitrogen, CSIRO, Hart Bros Seeds, FarmLink Research, <u>http://www.agronomy2015.com.au/papers/agronomy2015final00161.pdf</u>



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Other research in south-eastern Australia indicated a pulse grown for grain or BM can produce concentrations of available soil N that are 42-92 kg N/ha higher than those following wheat or canola in the first cropping season after the legume was grown.

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This represents apparent mineralisation of 20-30 percent of the N originally present in the legume residues. In the second year, N concentrations are on average 18-34 kg N/ha, representing 10-12 per cent of the residue legume  $N.^{26}$ 

A general rule of thumb is that doubling a legume grain yield doubles the N benefit to the next crop.

Management practices that can promote N fixation and high post-harvest residual N levels to achieve this include:

- » Inoculate lupin seed with rhizobia before sowing to encourage high levels of nodulation
- » Aim for high yielding lupin crops
- Choose the right variety for soil type and environment
- » Optimise nutrient inputs (especially P)
- » Apply lime to boost soil pH
- » Effectively manage weeds, diseases and pests
- » Use soil water conservation practices
- » Use reduced/zero-tillage to improve water infiltration
- » Sow on time and to meet optimal plant density targets.<sup>27</sup>

## 4.20 Role of lupin in nutrient cycling

Researchers in WA are finding lupin can have an important role in nutrient cycling. This is driven by the plant's dominant and deep taproot being able to access nutrients, especially P and K, at depth and bring these closer to the surface.

This can increase nutrient availability to subsequent cereal crops, which tend to have a higher proportion of root systems in the shallower part of the soil profile.

The researchers carried out glasshouse trials in 2013 investigating narrow leafed lupin root traits that underpin efficient P acquisition.

Trials and simulation modelling showed lupin plants supplied with banded P had the biggest root system and highest P-uptake efficiency.

Addition of P significantly stimulated root branching in the topsoil, whereas plants with nil P had relatively deeper roots.

The researchers demonstrated root hairs and root proliferation increased plant P acquisition and were more beneficial in the localised P fertilisation scenario.

They showed that placing P deeper in the soil might be a more effective fertilisation method, with greater P uptake than when using topdressing.

The combination of P foraging strategies (including root architecture, root hairs and root growth plasticity) was shown to be important for efficient P acquisition from a localised source of fertiliser.<sup>28</sup>



<sup>26</sup> Peoples, M, Swan, T, Goward, L, Hunt, J, Li Guangdi Li, Harris, R, Ferrier, D, Browne, C, Craig, S, Van Rees, H, Mwendwa, J, Pratt, T, Turner F, Potter, T, Glover, A, Midwood, J (2015) Legume effects on soil N dynamics – comparisons of crop response to legume and fertiliser N, CSIRO, NSW DPI, Birchip Cropping Group, CropFacts, Central West Farming Systems, FarmLink, MacKillop Farm Management Group, Yeruga Crop Research, Riverine Plains Inc, Southern Farming Systems, <u>https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/Legume-effects-on-soil-N-dynamics--comparisons-of-crop-response-to-legume-and-fertiliser-N</u>

<sup>27</sup> GRDC (2014) Fact Sheet – Nitrogen fixation of crop legumes: basic principles and practical management, <u>www.grdc.com.au/GRDC-FS-NFixation-Legumes</u>

<sup>28</sup> Chen, Y, Dunbabin, D, Postma, J, Diggle, A, Siddique, K, Rengel, Z (2013) Modelling root plasticity and response of narrow leafed lupin to heterogeneous phosphorus supply. UWA. <u>http://research-repository.uwa.edu.au/en/publications/modelling-root-plasticity-andresponse-of-narrowleafed-lupin-to-heterogeneous-phosphorus-supply(Idc591a6-de98-4083-a220-e17bda9e138).html</u>



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# MORE INFORMATION

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DPIRD 'Effects of Soil Acidity': <u>https://</u> www.agric.wa.gov.au/soil-acidity/ effects-soil-acidity

DPIRD 'Soil acidity – A guide for WA Farmers and Consultants': https://www.wheatbeltnrm.org.au/ sites/default/files/knowledge\_hub/ documents/Soil-acidity-farmersguide-Bulletin-4784-for-screen.pdf



# 4.21 Lupin, nutrients and soil constraints

The dominant taproot of narrow leafed lupin plants can delve as deep as 2.5 m, which is significantly deeper than field pea and barley – but varies with variety and soil type.

In narrow leafed lupin, lateral roots branch out from the taproot and there is a higher proportion of root material below 20 cm in the soil than in wheat plants.

Albus lupin varieties have a more extensive lateral root system and are better adapted to shallower, finer-textured soils.

Typically, lupin root hairs have less resistance to water flow than cereal roots and the plant can take up more water and nutrients from deeper in the soil profile.

But root penetration can be limited on hard-setting soils and where subsurface hardpans exist, as roots tend to favor pathways with low levels of impediments.

There is global research that has shown some crop roots will explore soil cracks and spores, which may allow penetration of hardpans and access to underlying water and nutrients.

Unlike WA, the south eastern cropping region has only small areas where soil acidity (low pH) is a significant impediment to lupin grain production. But these areas are expanding as parts of higher rainfall zones acidify.

For lupin, acidity in topsoils mainly affects nutrient availability and nodulation and is, most pronounced when pH is less than 5.5.<sup>29</sup>

When subsurface pH falls below 4.8, this can affect crop root cell division and the ability of the root to penetrate to depth, branch out and access deep stored water and nutrients. This is most noticeable when there is a dry finish to the growing season.

Liming the topsoil and incorporating lime to depth using a range of soil amelioration tactics has been shown to be effective in boosting soil pH and reducing Al to non-toxic levels on WA soils.<sup>30</sup>



<sup>29</sup> Gazey, C, Davies, S (2009) Soil Acidity – A guide for WA farmers and consultants, DAFWA, <u>https://www.wheatbeltnrm.org.au/sites/</u> default/files/knowledge\_hub/documents/Soil-acidity-farmers-guide-Bulletin-4784-for-screen.pdf

<sup>30</sup> Gazey, C, Davies, S (2009) Soil Acidity – A guide for WA farmers and consultants, DAFWA, <u>https://www.wheatbeltnrm.org.au/sites/</u> default/files/knowledge\_hub/documents/Soil-acidity-farmers-guide-Bulletin-4784-for-screen.pdf


### i) MORE INFORMATION

GRDC 'Integrated Weed Management Manual': <u>www.grdc.com.au/IWMM</u>

GRDC 'Integrated Weed Management Hub': <u>www.grdc.com.au/Resources/</u> <u>IWMhub</u>

GRDC Fact Sheet 'Stewardship for pre-harvest application of herbicides in winter crops': <u>https://grdc.com.</u> <u>au/resources-and-publications/</u> <u>all-publications/factsheets/2017/11/</u> preharvest-herbicide-use-fact-sheet

GRDC 'Grain Legume Handbook – Chapter 5 Weed Control': <u>https://grdc.</u> <u>com.au/grainlegumehandbook</u>

GRDC 'Fact Sheet – In-crop Herbicide Use': <u>grdc.com.au/GRDC-FS-</u> InCropHerbicideUse

GRDC 'Weed seedbank Destruction Video': <u>https://www.youtube.com/</u> watch?v=6nTo\_n47TxE#t=12

GRDC 'Weed ID: The Ute Guide' App: https://grdc.com.au/apps

GRDC 'Ground Cover Supplement – Herbicide Resistance': <u>https://grdc.</u> <u>com.au/Media-Centre/Ground-Cover-</u> Supplements/GCS104

WeedSmart: www.weedsmart.org.au

WeedSmart App: <u>https://grdc.com.</u> <u>au/apps</u>

Pulse Australia 'Lupins Weed Management': <u>http://www.pulseaus.</u> <u>com.au/growing-pulses/bmp/</u> <u>lupin#weed-management</u>

HerbiGuide: <u>http://www.herbiguide.</u> <u>com.au/</u>

Australian Glyphosate Sustainability Working Group: <u>http://www.</u> glyphosateresistance.org.au/

# Weeds and herbicides

### 5.1 Overview

When planting lupin crops in the southern region, best practice weed control involves an integrated weed management (IWM) plan.

This is particularly important for this crop, as lupin is known to be a poor competitor with weeds – especially early, before canopy closure.

The most widely accepted, efficient and cost effective methods of weed control in the southern region typically include the use of selective herbicides to remove grass weeds in broadleaf crops and broadleaf weeds in cereal crops.

An effective kill of grassy weeds in the pulse crop can also help reduce soil-borne root disease carry over and provide a break crop benefit to the following cereal crop.

Herbicides are available that can help control most grassy weeds in pulses and volunteer cereals can also be controlled with some of these products.

Simazine (Group C) alone and in mixtures with trifluralin (Group D) in lupin crops can be used to control or suppress some grasses that are not readily controlled by the specific grass herbicides.

In general, options for broadleaf weed control with selective herbicides in pulse crops are limited, compared to the treatments available for use in cereal crops.

Major weeds that impact on lupin production in South Australia, Victoria and New South Wales are:

- » Annual ryegrass (Lolium rigidum)
  - » Wild oats (Avena fatua L.)
  - » Brome grass (Bromus diandrus and B. rigidus)
  - » Barley grass (Hordeum)
  - » Wild radish (Raphanus raphanistrum L.).

Other weeds impacting on lupin productivity in the southern region include:

- » Capeweed (Arctotheca calendula)
- » Silver grass (*Miscanthus sinensis*)
- » Wild mustard (Sisymbrium orientale)
- » Doublegee (Emex australis)
- » Common sowthistle (Sonchus oleraceus).

If weed control is a priority, it is recommended lupin crops are sown after the break of season to obtain an effective weed knockdown. This ensures good soil moisture is available to activate soil herbicides, such as simazine.

Effective use of pre-emergence herbicides results in fewer weeds in the crop and this puts less pressure on post-emergent herbicide use.





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## (i) MORE INFORMATION

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Pulse Australia 'Residual Herbicides and Weed Control' hub: <u>http://www.</u> <u>pulseaus.com.au/growing-pulses/</u> <u>publications/residual-herbicides</u>

NSW Department of Primary Industries 'Weed control for winter crops 2016': www.dpi.nsw.gov.au/

GRDC Fact Sheet 'Stewardship for pre-harvest application of herbicides in winter crops': <u>https://grdc.com.</u> <u>au/resources-and-publications/</u> <u>all-publications/factsheets/2017/11/</u> preharvest-herbicide-use-fact-sheet

Agriculture Victoria 'Victorian winter crop summary': <u>http://agriculture.vic.</u> gov.au/agriculture/grains-and-othercrops/crop-production/growing-lupin

Agriculture Victoria 'Avoiding crop damage from residual herbicides': http://agriculture.vic.gov.au/ agriculture/farm-management/ chemical-use/agriculturalchemical-use/chemical-residues/ managing-chemical-residues-incrops-and-produce/avoiding-cropdamage-from-residual-herbicides

NVT online: www.nvtonline.com.au/

NVT Herbicide Tolerance information: http://www.nvtonline.com.au/wpcontent/uploads/2013/03/Herbicide-Tolerance-WA-Lupin-1998-2006.pdf

### 5.2 Herbicide types and use

The two types of herbicides are residual and non-residual. Residual types remain active in the soil for an extended period (months) and can act on successive weed germinations. Residual herbicides must be absorbed through the roots or shoots, or both.

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Examples of residual herbicides include isoxaflutole, imazapyr, chlorsulfuron, atrazine and simazine. The persistence of residual herbicides is determined by a range of factors including application rate, soil texture, organic matter levels, soil pH, rainfall and irrigation, temperature and the herbicide characteristics. The persistence of herbicides will affect the enterprise crop rotation.

Non-residual herbicides, such as the non-selective paraquat and glyphosate, have little or no soil activity and are quickly deactivated in the soil. They are either broken down or bound to soil particles, becoming less available to growing plants. They also may have little or no ability to be absorbed by roots.

Herbicides are applied pre or post-emergent. Pre-emergent refers to application of the herbicide to the soil before weeds have emerged. Post-emergent refers to foliar application of the herbicide after the target weeds have emerged from the soil.

A list of herbicide modes of action can be found here <u>https://www.croplife.org.au/</u> resistance-strategy/2017-herbicide-mode-of-action-groups/

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has a complete list of registered herbicide products and actives at <u>https://apvma.gov.au/</u>

### 5.3 Managing residual herbicide issues

Lupin crops can be affected by herbicide residues where rainfall has been insufficient in both summer and the previous growing season.

Lupin has particular sensitivity to Group B sulfonamide residues and, in high pH soils, some sulfosulfuron active residues can create problems.



**Figure 1:** A lupin plant showing shrivelling from Group B herbicide damage (sulfonylurea). (SOURCE: Tony Cook)





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All pulses, including lupin, are vulnerable to Group I phenoxy residues (such as 2,4-D amine and MCPA), particularly in sandy soils with low rates of microbial breakdown.

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Clopyralid is another Group I active that has shown significant residual effects in lupin crops the following season after summer application in some areas of the southern region. The Group I chlorophenoxy herbicide Dicamba can be an issue if it is used in autumn prior to sowing lupin crops in some areas. Other Group I amicide formulations tend to result in more residual issues than ester formulations in some regions and situations.

There may also be residue issues arising from the use of some newer herbicide options, such as the Group K metolachlor-prosulfocarb combination, Group C terbuthylazine and Group K dimethenamid, as outlined below.



**Figure 2:** Some Group C herbicides can cause damage to lupin plants, as shown here with necrotic leaf tips that are rolled and fold in a claw shape. (SOURCE: DPIRD)

For long-term, effective and sustainable weed control and herbicide efficacy, the key is to use a combination of herbicide, physical and cultural management tactics.

Newer narrow leafed lupin varieties, such as PBA Bateman<sup>¢</sup>, PBA Jurien<sup>¢</sup>, PBA Barlock<sup>¢</sup> and Mandelup<sup>¢</sup>, have been shown to be higher yielding than older varieties under weed pressure and have better tolerance to some key herbicides, as illustrated in Table 1 (from data in NSW).







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 Table 1: Lupin variety herbicide tolerance, NSW.

## The sensitivity of the variety compared to unsprayed controls of the same variety is summarised, using the following symbols based on the yield responses across all trials:

- N (narrow margin) significant yield reductions at higher than recommended rate in 1+ trials ONLY.
- x% yield reduction (warning) significant yield reduction at recommended rate in 1 trial only.
- x-y% yield reductions (warning) significant yield reductions at recommended rate in 2+ trials.
- not tested or only tested at higher than recommended rate (Please check Preliminary Evaluation tables)
- $\checkmark$  no significant yield reductions at higher than recommended rates in (Z) trials

Always follow label recommendations. All pesticide applications must accord with the currently registered label forthat particular pesticide, crop, pest and region. Any research regarding pesticides or their use reported in this website does not constitute a recommendation for that particular use by the authors, the author's organisations or ACAS. It must be emphasised that crop tolerance and yield responses to herbicides are strongly influenced by seasonal conditions.

		Triflur®480® IBS	Stomp® IBS	Terbyne <sup>®</sup> IBS	Boxer Gold <sup>®</sup> IBS	Simagranz 900g/litre	Brodal <sup>®</sup> Options 8-10 Leaf	Eclipse <sup>®</sup> 100SC	Eclipse® 6-10 leaf	Avadex®Xtra IBS	Status®	Sencor750 <sup>®</sup> PSPE	Sniper® 2-6 Leaf	Sencor750® 6-10leaf	Terbyne <sup>®</sup> PSPE	Simagranz® 900 Cot- 2leaf	Diflufenican + metribuzin	Gesatop + Gesaprim	Diuron®500 IBS	Eclipse® + Brodal® 2-6 leaf
Herbicide		Trifluralin	Pendimethalin	Terbyne	Boxer Gold	Simazine	Diflufenican	Metosulam	Metosulam	Triallate	Clethodim	Metribuzin	Picolinafen	Metribuzin	Terbyne	Simazine	Diflufenican + metribuzin	Simazine = Atrazine	Diuron	Metosulam + Diflufenican
Variety	Years tested	2000- 2015	1997- 2014	2010- 2015	2008, 09,15	1998- 2015	1996- 2015	1996- 2015	1996- 2008	2002- 2010	1999, 2013- 2015	1997- 2015	2000- 2012	2004- 2012	2010	2010	2003	2009	2009	2009
COROMUP	2008	🖌 (1)	🖌 (1)	-	-	N (1/1)	🖌 (1)	N (1/1)	-	-	-	🖌 (1)	🖌 (1)	N (1/1)	-	-	-	-	-	-
GUNYIDI	2014	🗸 (1)	🗸 (1)	🗸 (1)	-	🗸 (1)	🗸 (1)	🖌 (1)	-	-	🖌 (1)	🗸 (1)	-	-	-	-	-	-	-	-
JENABILLUP	2010- 2015	✓ (4)	✓ (3)	8 (1/3)	🖌 (1)	✓ (4)	N (1/4)	12 (1/4)	-	-	10 (1/3)	✓ (4)	-	-	🗸 (1)	-	N (1/1)	N (1/1)	-	-
JINDALEE	1997- 2014	N (1/10)	N (1/10)	✓ (2)	-	N (2/11)	N (2/8)	13-15 (2/8)	N (1/6)	✓ (2)	N (1/2)	✓ (8)	N (1/4)	N (1/2)	🗸 (1)	-	🗸 (1)	7 (1/1)	-	-
KALYA	1998- 1999	-	-	-	-	✓ (2)	11 (1/1)	N (1/2)	🗸 (1)	-	🗸 (1)	✓ (2)	-	-	-	-	-	-	-	-
KIEV MUTANT	1996- 2008	✓ (8)	✓ (8)	-	-	N (5/9)	N (1/6)	✓ (7)	✓ (8)	✓ (2)	🗸 (1)	N (2/6)	N (1/5)	N (2/3)	-	-	-	-	-	-
LUXOR	2004- 2015	✓ (7)	✓ (7)	6 (1/4)	11 (1/3)	N (2/7)	✓ (7)	✓ (6)	✓ (1)	✓ (2)	✓ (3)	N (2/7)	<b>√</b> (3)	N (3/3)	12 (1/2)	N (1/1)	N (1/1)	N (1/1)	✓ (1)	8 (1/1)
MAGNA	1999	-	-	-	-	🖌 (1)	-	🖌 (1)	🖌 (1)	-	🖌 (1)	🖌 (1)	-	-	-	-	-	-	-	-
MANDELUP	2001- 2015	✓ (8)	✓ (8)	9 (1/4)	N (1/3)	N (2/8)	N (1/7)	13 (1/6)	N (1/2)	8 (1/3)	14 (1/3)	N (2/7)	N (2/4)	N (2/3)	N (1/2)	🖌 (1)	N (1/1)	N (1/1)	🗸 (1)	🗸 (1)
MERRIT	1996- 1999	-	🗸 (1)	-	-	✓ (2)	✓ (3)	13 (1/4)	14 (1/3)	-	🗸 (1)	✓ (2)	-	-	-	-	-	-	-	-
MOONAH	2000- 2002	✓ (1)	-	-	-	N (1/1)	🗸 (1)	N (1/1)	N (1/1)	-	-	✓ (1)	-	-	-	-	-	-	-	-
MYALLIE	1996- 1999	-	-	-	-	✓ (2)	✓ (2)	N (2/3)	19 (1/2)	-	🗸 (1)	✓ (2)	-	-	-	-	-	-	-	-
PBA BARLOCK	2013- 2015	N (1/3)	✓ (2)	✓ (1)	✓ (1)	✓ (3)	✓ (3)	✓ (3)	-	-	✓ (3)	✓ (3)	-	-	🗸 (1)	-	-	-	-	-
PBA GUNYIDI	2010- 2015	✓ (3)	✓ (2)	🖌 (1)	🖌 (1)	✓ (3)	✓ (3)	✓ (3)	-	-	✓ (2)	✓ (3)	-	-	🗸 (1)	-	🖌 (1)	N (1/1)	-	-
PBA JURIEN	2014- 2015	✓ (2)	N (1/1)	🖌 (1)	✓ (1)	✓ (2)	N (1/2)	N (1/2)	-	-	12 (1/2)	19 (1/2)	-	-	-	-	-	-	-	-





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		Triflur®480® IBS	Stomp <sup>®</sup> IBS	Terbyne <sup>®</sup> IBS	Boxer Gold® IBS	Simagranz 900g/litre	Brodal® Options 8-10 Leaf	Eclipse <sup>®</sup> 100SC	Eclipse® 6-10 leaf	Avadex®Xtra IBS	Status®	Sencor750 <sup>®</sup> PSPE	Sniper <sup>®</sup> 2-6 Leaf	Sencor750 <sup>®</sup> 6-10leaf	Terbyne <sup>®</sup> PSPE	Simagranz® 900 Cot- 2leaf	Diflufenican + metribuzin	Gesatop + Gesaprim	Diuron <sup>®</sup> 500 IBS	Eclipse® + Brodal® 2-6 leaf
Herbicide		Trifluralin	Pendimethalin	Terbyne	Boxer Gold	Simazine	Diflufenican	Metosulam	Metosulam	Triallate	Clethodim	Metribuzin	Picolinafen	Metribuzin	Terbyne	Simazine	Diflufenican + metribuzin	Simazine = Atrazine	Diuron	Metosulam + Diflufenican
Variety	Years tested	2000- 2015	1997- 2014	2010- 2015	2008, 09,15	1998- 2015	1996- 2015	1996- 2015	1996- 2008	2002- 2010	1999, 2013- 2015	1997- 2015	2000- 2012	2004- 2012	2010	2010	2003	2009	2009	2009
QUILINOCK	2000- 2005	✓ (7)	✓ (6)	-	-	N (1/7)	N (1/3)	<b>√</b> (3)	N (2/5)	✓ (2)	-	N (2/4)	N (1/4)	N (1/2)	-	-	-		-	-
ROSETTA	2004- 2015	✓ (7)	✓ (7)	N (1/4	) 🗸 (3)	N (1/7)	✓ (7)	N (1/6)	🖌 (1)	✓ (2)	✓ (3)	N (2/7)	<b>√</b> (3)	N (2/3)	N (1/2)	4 (1/1)	-	-	🖌 (1)	🗸 (1)
TANJIL	1998	-	-	-	-	🗸 (1)	🖌 (1)	N (1/1)	-	-	-	N (1/1)	-	-	-	-	-	-	-	-
WALAN2448	2014- 2015	✓ (2)	🖌 (1)	🖌 (1)	🖌 (1)	✓ (2)	✓ (2)	✓ (2)	-	-	10 (1/2)	✓ (2)	-	-	-	-	-	-	-	-
WALAN2474	2014	10 (1/1)	🖌 (1)	🖌 (1)	-	✓ (1)	✓ (1)	9 (1/1)	-	-	11 (1/1)	🗸 (1)	-	-	-	-	-	-	-	-
WALAN2498	2015	🗸 (1)	-	-	🗸 (1)	🗸 (1)	🖌 (1)	🖌 (1)	-	-	🖌 (1)	🖌 (1)		-	-	-	-	-	-	
WK338	2014- 2015	✓ (2)	🗸 (1)	🗸 (1)	✓ (1)	✓ (2)	✓ (2)	✓ (2)	-	-	✓ (2)	N (1/2)	-	-	-	-	-	-	-	
WONGA	1996- 2010	✓ (8)	✓ (9)	N (1,1)	14 (1,2)	N (2,10)	N (2,7)	8 (1,8)	14-24 (2,7)	✓ (4)	✓ (1)	N (2/7)	N (1/5)	N (2/3)	N (1/1)	🖌 (1)	N (1/1)	N (1/1)	16 (1/1)	🗸 (1)
Rates (product	t/ha)	1.7L	3.0L	1.4L	2.5L	1.66L	200ml	70ml	10g	1.6L	375ml	380g	50g	380g	1.0L	550g	100ml +150g	1.3kg +650g	2.0L	7g + 100ml
Crop stage at spraying		IBS	IBS	IBS	IBS	PSPE	8-10 leaf	2-6 leaf	6-10 leaf	IBS	4 leaf	PSPE	2-6 leaf	6-10 leaf	PSPE	Cot-2 leaf	PSPE	IBS	IBS	2-6 leaf
		Eclipse® 2-6 leaf	Gesatop®900W + Brodal	Simazine 4-6 leaf	Sencor750® + Brodal	Silia∠lite900 + Bloual° +•9 leal Dual Gold® IBS	Dual Gold® PSPE	Motsa®	Simazine + Brodal® IBS	Simazine + Brodal® PSPE	Simazine + Brodal® 6-10 leaf	Eclipse <sup>®</sup> Mid-flowering	Eclipse® mid-podding	Targa®	Eclipse® + Brodal® 4-8 leaf	Verdict®520	Sertin®	Simazine + Atrazine IBS Simazine + Atrazine PSPE	Simazine + Trifluralin IBS	sakura®850WG IBS
Herbicide		Metosulam	Simazine + Diflufenican	Simazine	Metribuzin + Diflufenican Simocino +	diflufenican S-Metolachlo	S-Metolachlor	Clethodim + Halovvfon	Simazine + Diflufenican	Simazine + Diflufenican	Simazine + Diflufenican	Metosulam	Metosulam	Quizalofop-P- ethyl	Metosulam + Diflufenican	Haloxyfop-R	Sethoxydim	Simazine + Atrazine Simazine +	Atrazine + Simazine +	Atrazine Sakura®850WG
Variety	Years tested	2009	2009	2004	2004 2	005 20	02- 04 200	)2 200	4 1998	1997- 2002	1996	2002-	2002-	2002	2001	1998- 1 2001 -	1998- 1 2000 1	997- 199 998 20	98- 00 1993	3 2012
COROMUP	2008	-	-	-		-	-	-	-	-	-	-	-	-	-			-	-	-
GUNYIDI	2014	-	-	-		-	-	-	-	-	-	-	-	-	-			-	-	-
JENABILLUP	2010- 2015	-	-	-		-	-	-	-	-	-	-	-	-	-		<ul> <li>(1) -</li> </ul>	-	-	N (1/1)
JINDALEE	1997- 2014	-	-	🗸 (1)	N (1/1)	I (1/1) 8 (	1/1) <b>/</b>	✓ (1	) 🗸 (1)	✓ (2)	-	7 (1/2)	✓ (2)	🗸 (1)	🗸 (1)	✔ (3)	<b>/</b> (3)	16 2) (1/2)	2) 🗸 (	1) -



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Simazine900 + Brodal<sup>®</sup> 4-6 leaf Simazine + Brodal<sup>®</sup> 6-10 leaf Eclipse® + Brodal® 4-8 leaf Simazine + Atrazine PSPE Gesatop®900W + Brodal Simazine + Brodal<sup>®</sup> PSPE Simazine + Trifluralin IBS Simazine + Atrazine IBS Simazine + Brodal<sup>®</sup> IBS Eclipse<sup>®</sup> Mid-flowering Eclipse<sup>®</sup> mid-podding Sencor750<sup>®</sup> + Brodal Sakura<sup>®</sup>850WG IBS Simazine 4-6 leaf Dual Gold<sup>®</sup> PSPE Eclipse<sup>®</sup> 2-6 leaf Dual Gold<sup>®</sup> IBS Verdict<sup>®</sup>520 **Motsa**<sup>®</sup> Sertin<sup>®</sup> Targa® Sakura®850WG Quizalofop-P-ethyl Metosulam + Diflufenican S-Metolachlor S-Metolachlo Metribuzin + Diflufenican Simazine + Diflufenican Simazine + Diflufenican Simazine + Diflufenican Haloxyfop-R Diflufenican Metosulam diflufenican Clethodim + Haloxyfop Metosulam Metosulam Sethoxydim Simazine + Simazine + Simazine 4 Simazine ⊦ Atrazine Simazine -Simazine Atrazine Atrazine Herbicide 1997-Years 2002-1997 2002-2002 1998-1998-1998-Variety 2009 2009 2004 2004 2005 2002 2004 1998 1996 2002 2001 1998 2012 2004 2002 2000 1998 2000 2003 2003 2001 tested 1998-KALYA 🖌 (1) (1) (1) \_ 🖌 (1) 🖌 (1) 🖌 (1) -1999 (1/2) KIEV 1996-Ν N (1/1) ✓ (3) N (1/2) (1) (1) (1) ✓ (2) (1) ✓ (2) 🖌 (1) 🗸 (1) 🗸 (1) MUTANT 2008 (3) (2/2)2004 6 LUXOR ✓ (1) (1) ✓ (1) 2015 (1/1) MAGNA 1999 **/** (1) N (1/1) -\_ 2001-Ν Ν Ν 8 (1/1) MANDELUP 🖌 (1) ✓ (1) 🖌 (1) (1) (1) \_ (1/1) (1/1) 2015 (1/1) 1996 Ν MERRIT (1) ✓ (2) (1) 🖌 (1) ✓ (1) 1999 (1/1)(1/2)(1/2) 2000-MOONAH ✓ (1) ✓ (1) (1) 2002 1996-Ν Ν MYALLIE **/** (1) (1) (1) 🖌 (1) (1) ✓ (1) (1/1) (1/2)1999 PBA 2013--\_ BARLOCK 2015 2010-PBA ✓ (1) **GUNYIDI** 2015 2014-PBA JURIEN 2015 2000-14 12 QUILINOCK 🖌 (1) N (1/1) 🖌 (1) N (1/1) ✓ (2) 🖌 (1) ✓ (2) -**/** (1) **√** (1) (1) ✓ (2) -(1/2 (3) 2005 (1/1)2004 1 ROSETTA 🖌 (1) (1) (1) -2015 (1) TANJIL 1998 ✓ (1) (1) (1) (1) (1) 2014-WALAN2448 2015 WALAN2474 2014 **WALAN2498** 2015 \_ ---\_ 2014-WK338 2015 1996 21 15 1 22 13 1 Ν 🖌 (1) 🖌 (1) 🖌 (1) WONGA 🖌 (1) 🖌 (1) N (1/1) 🖌 (1) 🖌 (1) 🗸 (3) ✓ (2) N (1/1) 🗸 (3) ✓ (2) -2010 (1/1) (1/1) (3) (1/1) (1/2) (2) (2/3) 133g+ 1.0L+ 2.0L+ 2.0L+ 2.0L+ 556g+ 1.0L+ 1.0L+ 5g+ 1.5L+ 1.5L 1.0L 1.0L 300ml 375ml 100ml 1.0L 118g Rates (product/ha) 70ml 7g 7g 100ml 150ml 100ml 150ml 75ml 150ml 200ml 1.0L 1.0L 1.5L

(SOURCE: NVT Online)

Crop stage at

spraying

2-6

leaf

2-6

leaf

4-6

leaf

4-6

leaf

IBS

3-leaf

6-8

leaf

IBS

PSPF

8-10

leaf

PSPF

Mid

flower pod

Mid

2-6

leaf

4-8

leaf

6-10

leaf



PSPE IBS IBS

IBS

6 leaf



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### 5.3.1 Tips for managing newer herbicide options

It is recommended, if using the Group K and Group E metolachlor and prosulfocarb Boxer Gold® herbicide as a pre-emergent, to apply to soil surface up to seven days before sowing lupin crops and incorporate it mechanically through the seeding process.

Application should be into a moist seedbed and when the outlook is for sufficient rain to thoroughly wet the top 3-4 cm of soil within 10 days of application.

It is advised to use Boxer Gold®:

- In seeding systems that ensure accurate seed placement and adequate separation of seed and herbicide
- On soils not prone to waterlogging
- When there are no heavy rains likely to cause run-off forecast within two days of application.

It is advised to not use Boxer Gold® where:

- Seeding or tillage systems are used that cannot ensure accurate seed placement and adequate spatial separation of seed and herbicide
- Soils are prone to waterlogging, on sodic soils or soils affected by physical compaction
- Heavy rains or storms that are likely to cause run-off are forecast within two days of application.

Accuracy of seed placement is critical in ensuring crop selectivity. Unacceptable crop injury (such as reduction in crop vigour and yield loss) can potentially occur where there is inadequate spatial separation of seed and herbicide, or where heavy rainfall occurs during the early stages of crop establishment. Avoid soil throw into adjacent seeding rows or sites where furrow walls may collapse. Shallow sowing is not recommended due to the greater potential for movement of herbicide within close proximity of the emerging crop, especially in sandy soils.

Application of Boxer Gold<sup>®</sup> to crops sown in soils of high leaching potential and those low in clay or organic matter may result in crop damage. Avoid double spraying (overlapping) of the crop with herbicide

More information about this herbicide can be found at: <u>http://www.herbiguide.com.</u> <u>au/Descriptions/hg\_Boxer\_Gold.htm</u> can <u>https://www.syngenta.com.au/cereals/</u> <u>herbicides/boxer-gold</u>

If using the Group K pyroxasulfone herbicide Sakura<sup>®</sup> 850 WG, it is best applied just before sowing and incorporated by the seeding process using knife points and press wheels (avoiding throwing treated soil into adjacent rows) or narrow points and harrows.

Note that Sakura<sup>®</sup> 850 WG can only be applied before sowing a lupin crop and lupin cannot be sown for nine months after this herbicide is used in situations such as a failed establishment of a wheat crop.

If using Sakura® 850 WG, it is advised to apply if:

- There is no heavy rain forecast within two days of application
- Incorporation with seeding can be achieved within three days of application
- Soil is not waterlogged.

It is advised not to use Sakura® where:

- Heavy rain has been forecast within 48 hours of application
- Incorporation by sowing (IBS) cannot be performed within three days of application
- There are waterlogged soils.





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Other factors that may reduce weed control from Sakura® 850 WG include: uneven application; application to ridged or 'clodded' soils; high levels of stubble, plant residue or other ground cover; or if there is heavy rain on sandy soil types prone to leaching.

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More information about Sakura® 850 WG is available at: <u>https://www.crop.bayer.com.</u> <u>au/find-crop-solutions/by-product/herbicides/sakura-850-wg-herbicide</u>

If considering the Group C herbicide terbuthylazine, apply to lupin as Terbyne® Xtreme® 875 WG. This is best used at the lower registered rate on lighter soils (such as sandy loams and loamy sands) and at higher registered rates on heavier soils (such as loams or silt-clay).

Best results will come from ensuring lupin seed is covered with 3-5 cm of soil at seeding and when there is sufficient rainfall (about 20-30 mm) within two or three weeks of application to wet the soil right through the weed root zone.

It is recommended to apply Terbyne<sup>®</sup> Xtreme<sup>®</sup>, if being considered for use in lupin crops, if there are no heavy rains forecast for two days, soils are not waterlogged and at rates less than 0.86 kilograms per hectare on soils with a pH of 8 or more. Some early crop phytotoxicity may be observed, particularly on light soils. Heavy, intense rainfall following application may cause crop damage. At the higher rates, it is advised to avoid overlapping sprays and spraying-out corners.

The Group K herbicide dimethenamid-P, applied to lupin as Outlook<sup>®</sup>, controls annual ryegrass in low populations of typically less than 100 plants per square metre. It will act to only suppress weeds in higher populations.

It is advised, if using, to apply this herbicide as late as possible before sowing and to use a knifepoint and press wheel system before weeds germinate. Weeds that are emerging, or emerge soon after application, are typically unlikely to be controlled, necessitating the use of a post-emergent knockdown.

It is recommended if using Outlook® to apply if soil is moist, or rain is forecast within seven days of application, but there is not likely to be heavy rain within two days of application. Areas prone to waterlogging are best avoided.

More information about this herbicide is available at: <u>http://www.herbiguide.com.au/</u> informationherbicides.aspx





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### i) MORE INFORMATION

GRDC Integrated weed management hub 'Common sowthistle': <u>https://</u> <u>grdc.com.au/resources-and-</u> <u>publications/iwmhub/common-</u> <u>weeds-of-cropping/common-</u> <u>sowthistle</u>

GRDC 'Update Paper – Common Sowthistle and Flaxleaf Fleabane – Understanding the Weed's Lifecycles for Management Strategies that Work': <u>https://grdc.com.au/</u> <u>Research-and-Development/</u> <u>GRDC-Update-Papers/2009/09/</u> <u>COMMON-SOWTHISTLE-</u> <u>AND-FLAXLEAF-FLEABANE-</u> <u>UNDERSTANDING-THE-WEEDS-</u> <u>LIFECYCLES-FOR-MANAGEMENT-</u> <u>STRATEGIES-THAT-WORK</u>

GRDC 'YouTube – Ecology and Management of Common Sowthistle': <u>https://www.youtube.com/</u> watch?v=I\_5gm-ZhGE0

Seventeeth Australasian Weeds Conference 'Update Paper – Genetic Diversity among ALS-inhibiting Herbicide Resistant and Susceptibly Populations of *Sonchus oleraceus L*. (sowthistle) in Australia': <u>http://caws.</u> org.au/awc/2010/awc201012811.pdf



### 5.4 Broadleaf weed control in lupin crops

### 5.4.1 Sowthistle (Sonchus oleraceus)



**Figure 3:** Sowthistle is a major broadleaf weed affecting lupin crop production in the southern region.

(SOURCE: DPIRD)

- A major weed of fallow
- Uses vital stored soil moisture
- A prolific seed producer
- Difficult to control
- An alternate host for insects
- Populations in southern region resistant to Group B herbicides
- Four NSW populations resistant to glyphosate (Group M).<sup>1</sup>





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### Management and control of sowthistle

**Table 2:** Tactics that should be considered when developing an integrated plan to manage common sowthistle.<sup>2</sup>

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Common so (Sonchus ol	wthistle eraceus)	Most likely % control (range)	Comments on use
Agronomy	Improve crop competition	95 (75–99)	Increased competition results in lower weed pressure. Competition improves herbicide efficacy.
Tactic	Fallow and pre-sowing cultivation	80 (30-90)	Cultivation or full disturbance sowing buries seeds and prevents their germination.
Tactic	Knockdown (non-selective) herbicides for fallow and pre- sowing control	95 (75–99)	Better control is achieved when treating small weeds. A reduction in herbicide efficacy occurs when 2,4-D is tank-mixed with glyphosate due to antagonism within the plant.
Tactic	Selective post-emergent herbicides	95 (75–99)	Better control is achieved when treating small weeds.
Tactic	Spray-topping with selective herbicide	95 (75–95)	Seed reduction of escapes. Timing is critical to avoid crop damage.
Tactic	Grazing crop residues	95 (up to 100)	To control escapes in fallow before seedset. Common sowthistle is very palatable and is preferentially grazed.

Numerous populations of sowthistle across southern Australia are resistant to Group B herbicides, such as chlorsulfuron. Incidences now equal estimates of Group B resistance in the northern cropping region. This has rendered the weed a national problem in cropping and fallow situations.

Switching to alternative mode-of-action (MOA) herbicides is an effective management strategy. But the universal distribution of this species and widespread resistance to Group B herbicides is a future threat to cropping systems, according to researchers. Integrated use of cultural and chemical weed control methods can provide effective control of common sowthistle.<sup>3</sup>

Other management tactics to help control this weed in southern region lupin crops include:

- » Apply herbicides to small, non-stressed and actively growing weeds
- » Use a double-knock
- » If glyphosate resistance is an issue, treat before the 10 centimetres diameter rosette stage with a Group I herbicide followed by paraquat.<sup>4</sup>

2 GRDC (2016) Integrated Weed Management hub, weed profile 'Common sowthistle', <u>https://grdc.com.au/resources-and-publications/</u> iwmhub/common-weeds-of-cropping/common-sowthistle

3 GRDC (2009) Common sowthistle and flaxleaf fleabane – Understanding the weed's lifecycles for management strategies that work, GRDC, <u>https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2009/09/COMMON-SOWTHISTLE-AND-FLAXLEAF-FLEABANE-UNDERSTANDING-THE-WEEDS-LIFECYCLES-FOR-MANAGEMENT-STRATEGIES-THAT-WORK</u>

4 GRDC (2016) Integrated Weed Management hub, weed profile 'Common sowthistle', <u>https://grdc.com.au/resources-and-publications/</u> iwmhub/common-weeds-of-cropping/common-sowthistle





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Sowthistle is commonly a problem in zero or reduced tillage systems and occurs in both fallow and cropped areas.

It can be found on most soil types, but favors soils with a high water-holding capacity.

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This weed is a problem in many different production enterprises, including dryland and irrigated broadacre cereal production.

By including a range of management tactics as part of an IWM approach, the risk of resistance to glyphosate and other herbicide MOA will be reduced and management of already resistant populations will improve. This includes using a double-knock and strategic tillage.

The double-knock is a common tactic for the control of other weed species, including flaxleaf fleabane and awnless barnyard grass. It involves the sequential application of two different herbicides – where the second is applied to control survivors of the first.

It is advised that management strategies for common sowthistle should also take into account:

- » Glyphosate resistance (confirmed in the northern region)
- » Reported widespread Group B resistance
- » Targets for 100 percent elimination of seed set, including on road verges and in channels
- » An aim to maximise crop competition in the rotation.
- » There are no post-emergent herbicide options.<sup>5</sup>







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## (i) MORE INFORMATION

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GRDC 'Fact Sheet – Wild Radish': www.grdc.com.au/GRDC-FS-WildRadishManagement

GRDC Integrated weed management hub 'Wild radish': <u>https://grdc.com.au/</u> <u>resources-and-publications/iwmhub/</u> <u>common-weeds-of-cropping/wild-</u> <u>radish</u>

GRDC 'Herbicide Resistance Testing': www.grdc.com.au/Media-Centre/ Media-News/South/2014/04/ Herbicide-resistance-testingautumn-2014

DPIRD 'Wild Radish': <u>https://www.</u> agric.wa.gov.au/grains-researchdevelopment/wild-radish

Weed Seed Wizard: <u>https://www.</u> agric.wa.gov.au/weed-seed-wizard-0



5.4.2 Wild radish (Raphanus raphanistrum)

**Figure 4:** Wild radish affects lupin crop production in the southern region.

- One of the most widespread and competitive broadleaf weeds in Australia
- Can cause yield losses of 10-90 percent in lupin crops
- A prolific seeder with high seedbank dormancy
- Up to 70 percent of seeds still dormant in the next cropping season
- High resistance to some Group B and Group I herbicides (sulfonylureas, sulfonamides and phenoxy)
- Populations with resistance to some Group F and C herbicides
- Important to kill in-crop weeds while small
- Seeds become viable within three weeks of first flowers
- Retains seed pods at harvest height, making harvest weed seed control (HWSC) effective
- Long-term management requires driving seed numbers down to low levels
- Hand picking of resistant plants in-crop is being evaluated.<sup>6,7</sup>



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<sup>6</sup> DPIRD (2016) Wild Radish, https://www.aaric.wa.gov.au/grains-research-development/wild-radish

<sup>7</sup> GRDC (2014) Fact Sheet – Wild radish, www.grdc.com.au/GRDC-FS-WildRadishManagement



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### Management and control of wild radish

Table 3: Tactics that should be considered when developing an integrated plan to manage wild radish.<sup>8</sup>

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Wild radish (Raphanus r	aphanistrum)	Most likely % control (range)	Comments on use
Agronomy	Herbicide tolerant crops	90 (80–99)	If growing canola in a wild radish infested area it is best to use a herbicide resistant variety and associated herbicide package.
Tactic	Burning residues	70 (20–90)	In concentrated windrows. Burn when conditions are conducive to a hot burn.
Tactic	Inversion ploughing	98 (20-100)	Plough must be correctly 'set up' and used under the right conditions. Must use skimmers.
Tactic	Autumn tickle	45 (15–65)	Follow-up rain is needed for better response.
Tactic	Knockdown (non-selective) herbicides for fallow and pre- sowing control	80 (70–90)	Add a reliable herbicide spike for more reliable control. Late germinations will not be controlled.
Tactic	Selective post-emergent herbicides	90 (70–99)	Apply to young and actively growing weeds. Repeat if necessary to control late emerging weeds or survivors.
Tactic	Spray-topping with selective herbicides	80 (70–95)	Wild radish may regrow if there are late rains. Good for seedset control. Spray before embryo development for best results.
Tactic	Wiper technology	70 (50–80)	Has potential in low growing pulses such as lentils
Tactic	Silage and hay – crops and pastures	80 (70–95)	Cut before embryo formation in developing wild radish seed (21 days after first flower). Graze or spray regrowth.
Tactic	Manuring, mulching and hay freezing	95 (90–100)	Brown manuring more efficient than green manuring and more profitable. Grazing before spraying to open sward will improve results. Hay freezing works well and is the most profitable manuring option in most cases.
Tactic	Grazing – actively managing weeds in pastures	70 (50–80)	Rotationally graze and use spray- grazing. Can also use slashing to improve palatability and reduce pasture growth rate in spring.
Tactic	Weed seed collection at harvest	75 (65–85)	Most reliable in early harvested paddocks
Tactic	Sow weed-free seed	95 (90-100)	Very important as resistance in wild radish is increasing and introduction via crop seed is increasingly likely

8 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.</u> <u>agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>





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High seed dormancy and increasing levels of herbicide resistance make wild radish difficult to control in lupin crops, which are also poor competitors with this weed.

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Lowering the wild radish seedbank can take up to 10 years, as any plants that survive one season to set seed will replenish the soil with a new wave of dormant seed that can take up to 18 months to germinate.<sup>9</sup>

Wild radish tends not to be highly damaging to lupin yield potential very early in the growing season in most areas of the southern region. This means post-emergent control was effective until herbicide resistance emerged as an issue.

Effective control in the lupin phase of the rotation requires an integrated management approach that can include tactics such as:

- » Testing seed from surviving wild radish plants at harvest for herbicide resistance
- » Application of glyphosate and/or paraquat herbicide during summer
- » A double herbicide application at full label rates when wild radish plants are small
- » Narrow row spacing or paired rows at seeding to boost crop competition
- » Harvest weed seed capture and destruction
- Weed detection technology if cost-effective
- » Use of decision-support tools, such as Weed Seed Wizard.<sup>10</sup>

The main post-emergent herbicides registered to control wild radish in lupin crops in the southern region are the Group F actives diflufenican and picolinafen and the Group B active metosulam in some varieties (such as Jindalee, Quilinock<sup> $\phi$ </sup> and Wonga<sup> $\phi$ </sup>).

There is widespread resistance to diflufenican herbicide in the southern region, which has reduced its effectiveness.

Wild radish with resistance to sulfonylureas (Group B) herbicides has also become widespread, making the use of Eclipse® herbicide in lupin crops less effective.

Tips for post-emergent herbicide use for wild radish in lupin crops include:

- » Use full label rates
- » Diflufenican is best for early control (but unlikely to kill big weeds)
- Metosulam can be used for later control in some varieties (Jindalee, Quilinock<sup>(b)</sup> and Wonga<sup>(b)</sup>)
- » Metosulam has been known to reduce yields in Moonah^{\! \ensuremath{\scriptscriptstyle 0}} and Mandelup  $^{\! \ensuremath{\scriptscriptstyle 0}}$
- » Paraquat can be applied at 80 percent leaf drop for desiccation of any surviving wild radish
- » Mixing broadleaf and grass herbicides will damage lupin crops and should be avoided.<sup>11</sup>

Wild radish can reduce lupin yields by decreasing pod number, grain size and germination rates.

Increasing lupin crop density to a target of 50 plants per square metre has been found to reduce the adverse yield effects of this weed.

Research has demonstrated that increased lupin crop density and competition with wild radish can be achieved by using a combination of:

- » High seeding rates of about 110 kg/ha
- » Narrow row spacing of 23 cm
- » Using east-west sowing row orientation in some areas.<sup>12</sup>
- 9 GRDC (2014) Fact Sheet Wild radish, <u>www.grdc.com.au/GRDC-FS-WildRadishManagement</u>
- 10 DPIRD (2016) Wild Radish, https://www.agric.wa.gov.au/grains-research-development/wild-radish
- 11 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>
- 12 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>





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GRDC Integrated weed management hub 'Wild /Indian hedge mustard': https://grdc.com.au/resources-andpublications/iwmhub/commonweeds-of-cropping/indian-hedgemustard

## **5.4.3** Wild mustard/Indian hedge mustard (*Sisymbrium orientale*)



**Figure 5:** Wild mustard is a prolific seed producer and is widespread across the southern region.

(SOURCE: Agronomo)

- Produces vast numbers of seeds up to 30,000/m<sup>2</sup>
- Causes problems at harvest
- Populations been found to be resistant to Group B and I herbicides
- Small seeds can cause grain contamination.<sup>13</sup>



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#### Management and control of wild mustard

 Table 4: Tactics that should be considered when developing an integrated plan to manage Indian hedge mustard.<sup>14</sup>

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Indian hedge (Sisymbrium o	mustard prientale)	Most likely % control (range)	Comments on use
Agronomy	Crop choice and sequence	85 (0-99)	Avoid crops with no post- emergent herbicide options.
Agronomy	Herbicide tolerant crops	80 (0-95)	Very useful for non-cereal portions of the rotation
Tactic	Autumn tickle	25 (10–50)	Use with early breaks to the season and combine with delayed sowing.
Tactic	Delayed sowing	95 (90–99)	Follow by knockdown with non-selective herbicides targeting small weeds.
Tactic	Knockdown (non-selective) herbicides for fallow and pre- sowing control	75 (50–80)	Use high rates to control biennial plants. Tank-mixing with phenoxy herbicides improves control in absence of Group I resistance. Late germinations are not controlled.
Tactic	Pre-emergent herbicides	75 (50–80)	Dry conditions post-sowing reduces herbicide efficacy.
Tactic	Selective post-emergent herbicides	80 (60–90)	Spray young actively growing plants and repeat if necessary. Be aware of resistance status.
Tactic	Spray-topping with selective herbicides	95 (85–99)	Be aware of resistance status. The control range assumes no Group B resistance.
Tactic	Wiper technology	80 (60–95)	Useful tactic in lentil
Tactic	Grazing – actively managing weeds in pastures	70 (50–80)	Rotationally graze. Use spray-grazing with herbicide suited to pasture species present.
Tactic	Weed seed collection at harvest	50 (10–70)	Useful on early harvested crops

(SOURCE: GRDC)15

Wild mustard is widespread and germinates in autumn and winter to compete with lupin crops.

Simazine is the pre-emergent herbicide option to control wild mustard in lupin crops in the southern region and diflufenican (Group F) can be used post-emergence.



<sup>14</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary</u>. agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

<sup>15</sup> GRDC (2016) Integrated Weed Management hub, weed profile 'Indian hedge mustard', <u>https://grdc.com.au/resources-and-publications/</u> iwmhub/common-weeds-of-cropping/indian-hedge-mustard



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GRDC Integrated weed management hub 'Wireweed': <u>https://grdc.com.</u> <u>au/resources-and-publications/</u> <u>iwmhub/common-weeds-of-cropping/</u> <u>wireweed</u>

### 5.4.4 Wireweed (Polygonum aviculare, P. arenastrum)

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**Figure 6:** Wireweed can be difficult to control in the southern region due to its tendency to have a delayed germination.

(SOURCE: Agronomo)

- Autumn to early summer germinating, annual or biennial
- Delayed germination makes control difficult
- Competes for moisture and nutrients
- Often causes problems with machinery
- Has phytotoxic properties.<sup>16</sup>





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 Table 5: Tactics that should be considered when developing an integrated plan to manage wireweed.<sup>17</sup>

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Wireweed ( <i>Polygonum</i> sp	p.)	Most likely % control (range)	Comments on use
Agronomy	Crop choice and sequence	80 (0–50)	Avoid continuous cereals or broadleaf crops where control is difficult. Avoid growing pulses in heavily infested paddocks. Wireweed increases in triazine tolerant canola.
Agronomy	Herbicide tolerant crops	90 (50–95)	Some imidazoline herbicides provide useful control in legume and imidazoline tolerant crops. Glyphosate will provide good control in glyphosate tolerant crops.
Agronomy	Fallow phase	80 (0-80)	Control early in the fallow to reduce vining (i.e. kill small plants).
Tactic	Inversion ploughing	90 (80–95)	Use once to bury resistant seed deeply then avoid bringing that seed back to the surface for at least 10 years.
Tactic	Knockdown (non-selective) herbicides for fallow and pre- sowing control	90 (75–90)	Glyphosate, dicamba and some sulfonylurea herbicides are the most effective.
Tactic	Pre-emergent herbicides	90 (50–80)	Trifluralin, pendimethalin, chlorsulfuron and triasulfuron provide good control, but are dependent on rain after application.
Tactic	Selective post-emergent herbicides	90 (75–90)	Metsulfuron and dicamba provide good control. Target small weeds for better control. Few options exist in broadleaf crops.
Tactic	Manuring, mulching and hay freezing	90 (50–80)	Good for controlling late germinations and reducing problems in summer fallow.

Wireweed tends to germinate during or after crop emergence and competes for soil moisture and nutrients.

Typically this weed does not affect lupin yields significantly, but it can cause problems in blocking sowing equipment and/or interfering with harvesting due to its lengthy branching. It can affect rhizobia bacteria required for lupin nodulation due to its phytotoxic properties and it is tolerant of atrazine.<sup>18</sup>

Pre-emergent herbicide options for control of wireweed in lupin crops in the southern region include trifluralin, pendimethalin (Group D) and simazine.

17 GRDC (2016) Integrated Weed Management hub, weed profile 'Wireweed', <u>https://grdc.com.au/resources-and-publications/iwmhub/</u> common-weeds-of-cropping/wireweed



<sup>18</sup> HerbiGuide, Wireweed, http://www.herbiguide.com.au/Descriptions/hg\_Wireweed.htm



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GRDC Integrated weed management hub 'Annual ryegrass': <u>https://grdc.</u> <u>com.au/resources-and-publications/</u> <u>iwmhub/common-weeds-of-cropping/</u> <u>annual-ryegrass</u>

GRDC/University of Adelaide 'Herbicides for Control of Clethodim-Resistant Annual Ryegrass': <u>www.grdc.com.au/</u> <u>Research-and-Development/GRDC-</u> <u>Update-Papers/2015/02/Herbicides-</u> <u>for-control-of-clethodim-resistant-</u> <u>annual-ryegrass</u>

GRDC/AHRI 'Update Paper – Why the Obsession with the Ryegrass Seedbank': <u>www.grdc.com.au/</u> <u>Research-and-Development/GRDC-</u> <u>Update-Papers/2015/02/Why-the-</u> <u>obsession-with-the-ryegrass-seed-</u> <u>bank</u>

HerbiGuide 'Annual Ryegrass': http://www.herbiguide.com.au/ Descriptions/hg\_Annual\_Ryegrass. htm

Ryegrass Integrated Management (RIM): <u>www.ahri.uwa.edu.au/RIM</u>



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### 5.5 Grass weed control in lupin crops

### 5.5.1 Annual ryegrass (Lolium rigidum)



**Figure 7:** Annual ryegrass in a cereal crop. (SOURCE: GRDC)

- Highly competitive as early as two-leaf stage
- Can cause lupin yield losses of 5 percent for every 25 annual ryegrass plants/m<sup>2</sup>
- Late sown crops affected more by weed competition
- Can produce up to 45,000 seeds/plant in ideal conditions
- About 80 percent seed germination after season break
- Several waves of germination typically make control difficult
- Can carry crop root diseases between seasons and years
- Seed cleaning costs may increase due to contamination by weed seeds
- Increasing levels of resistance to herbicides in southern Australia
- Multiple herbicide resistance to some selective/non-selective herbicides in SA
- HWSC can be effective, as seed is retained at harvest height.<sup>19,20</sup>



<sup>19</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>

<sup>20</sup> HerbiGuide, Annual Ryegrass, http://www.herbiguide.com.au/Descriptions/hg\_Annual\_Ryegrass.htm



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**Table 6:** Tactics that should be considered when developing an integrated plan to manage annual ryegrass.  $^{\rm 21}$ 

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Annual ryegras (Lolium rigidum	is 1)	Most likely % control (range)	Comments on use
Agronomy	Improve crop competition	50 (20–80)	Optimum sowing rates essential. Row spacing <250 mm to increase crop competitiveness. Sow on time.
Tactic	Burning residues	50 (0–90)	Avoid grazing crop residues. Use a hot fire back-burning with a light wind.
Tactic	Inversion ploughing	95 (80–99)	Bury seed greater than 100 mm deep. Use of skimmers on the plough is essential for deep burial.
Tactic	Autumn tickle	15 (0–50)	Only effective on last year's seedset. Use in conjunction with delayed sowing.
Tactic	Fallow and pre-sowing cultivation	60 (0–90)	Cultivation may lead to increased annual ryegrass in the crop. Use in combination with a knockdown herbicide. Use cultivators that bury seed.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	80 (30–95)	Avoid overuse of the one herbicide MOA group. Wait until annual ryegrass has more than 2 leaves.
Tactic	Double knockdown or 'double-knock'	95 (80–99)	Reduces the likelihood of glyphosate resistance. Use glyphosate followed by paraquat or paraquat + diquat 3 to 10 days later.
Tactic	Pre-emergent herbicides	70 (50–90)	Note incorporation requirements for different products and planting systems.
Tactic	Selective post-emergent herbicides	90 (80–95)	Apply as early as possible after the annual ryegrass has 2 leaves to reduce yield losses in cereals.
Tactic	Spray-topping with selective herbicides	80 (60–90)	Apply before milk dough stage of annual ryegrass.
Tactic	Crop-topping with non- selective herbicides	70 (50–90)	Note stage of crop compared to stage of annual ryegrass. Often not possible to achieve without crop yield loss. Most likely to occur with quick finish to season.
Tactic	Pasture spray-topping	80 (30–99)	Graze heavily in spring to synchronise flowering.
Tactic	Silage and hay – crops and pastures	80 (50–95)	Most commonly used where there is a mass of resistant annual ryegrass growth. Follow up with herbicides or heavy grazing to control regrowth.
Tactic	Manuring, mulching and hay freezing	90 (70–95)	Most commonly used where there is a mass of resistant annual ryegrass growth. Follow up with herbicides or heavy grazing to control regrowth.
Tactic	Grazing – actively managing weeds in pastures	50 (20-80)	Graze heavily in autumn to reduce annual ryegrass plant numbers. Graze heavily in spring to reduce seedset.
Tactic	Weed seed collection at harvest	65 (40-80)	Best results when crop is harvested as soon as possible before annual ryegrass lodges or shatters
Tactic	Sow weed-free seed	85 (50-99)	Reduces the risk of introducing resistant annual ryegrass to the paddock with crop seed



<sup>21</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary</u>. agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins



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Harvest weed seed control (HWSC), delaying sowing and/or using a double-knock with full label rates of glyphosate and paraquat before sowing lupin crops can be good options in heavily infested annual ryegrass paddocks, or to help manage herbicide resistance issues.

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When seasonal conditions are conducive, a light cultivation, or tickle, in autumn can encourage weed germination.

This will facilitate more effective annual ryegrass control with pre-seeding herbicide options, typically glyphosate and/or paraquat.

The most effective double-knock interval between glyphosate and paraquat application has been shown in many research trials to be between two and 10 days for seedling annual ryegrass plants.<sup>22</sup>

At sowing, Western Australian research has found increasing crop seeding rate and banding fertiliser below the lupin seed can improve lupin plant competition and help reduce annual ryegrass establishment and seed set. A target plant density of 40-45 plants/m<sup>2</sup> is recommended for narrow leafed lupin crops to be competitive with annual ryegrass and to optimise yield potential, but this will vary widely between locations and seasons. Using narrow row spacings (about 25 cm) has been found to improve weed control in lupin crops grown in cooler, longer-season environments.<sup>23</sup>

Pre-emergent herbicides registered for use to control annual ryegrass in lupin crops in the southern region are:

- » Simazine (Group C)
- » Trifluralin (Group D)
- » Pendimethalin (Group D)
- » Boxer Gold® (metolochlor + prosulfocarb Group J and K)
- » Sakura® (pyroxasulfone Group K)
- » Outlook<sup>®</sup> (dimethanemid-P Group K).
- Terbyne<sup>®</sup> Xtreme (terbuthylazine Group C).



**Figure 8:** *Simazine (Group C) can cause leaf stunting and crop damage.* (SOURCE: Tony Cook)



<sup>22</sup> GRDC (2014) Integrated Weed Management Manual: <u>www.grdc.com.au/IWMM</u>

<sup>23</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>



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The competition effect from annual ryegrass tends to be later in the season when lupin and weed plants vie for soil moisture.

Tips for pre-emergent herbicide applications for annual ryegrass control in lupin crops in the southern region include:

- » Simazine and trifluralin are most effective when incorporated in wet soil
- » Maximum rate of simazine (600 g/ha) registered for light and gravely loam soils is up to 1.7 L/ha

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- » It is recommended not to use simazine on deep white or grey/gritty sands
- » Trifluralin can be added if levels of grass weeds are expected to be high
- » To manage resistance issues, try to avoid trifluralin in multiple crops in the rotation
- » Trifluralin is added mainly for wireweed control
- » An integrated approach is most effective, with strategic use of grass herbicides and cultural grass control methods
- » Crop damage can occur from Group C pre-emergent herbicides, such as simazine.<sup>24</sup>

Post-emergent herbicides registered for use to control annual ryegrass in lupin crops are:

- » Haloxyfop (Group A)
- » Clethodim (Group A)
- » Sethoxydim (Group A)
- » Butroxydim (Group A)
- » Diclofop (Group A)
- » Fluazifop (Group A)
- » Quizalofop (Group A)
- » Propaquizafop (Group A)
- » Paraquat (Group L) for crop topping.

There are high levels of 'fop' resistant annual ryegrass in the southern region and fop chemicals used without a 'dim' partner are likely to have poor results, according to advisers.

Other tips for post-emergent herbicide applications to control annual ryegrass in southern region lupin crops include:

- » Spray small weeds early
- » Grass weeds need to be actively growing
- » Avoid spraying weeds stressed by dry soil, cold weather or frost
- » Use the highest registered label rate
- » Use the recommended adjuvant
- » Avoid mixing grass-selective and broadleaf herbicides
- If applying paraquat during the season (for desiccation) use before weed seed set
- » Test and monitor herbicide resistance status of annual ryegrass.<sup>25</sup>



<sup>24</sup> White, P. French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>

<sup>25</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>



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GRDC Integrated weed management hub 'Wild oats': <u>https://grdc.com.au/</u> resources-and-publications/iwmhub/ <u>common-weeds-of-cropping/wild-</u> <u>oats</u>

GRDC 'Ute Guide – Wild Oats': www.grdc.com.au/Resources/Ute-Guides/Weeds/Grass/West/Wild-oats

GRDC 'Podcast – Controlling Wild Oats': <u>https://grdc.com.au/Media-</u> <u>Centre/GRDC-Podcasts/Southern-</u> <u>Weekly-Update/2015/10/103-south</u>

HerbiGuide 'Wild oats': www.herbiguide.com.au/ Descriptions/hg\_Wild\_Oat.htm





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**Figure 9:** Group A resistant Wild oats on the inter-row of wheat. (SOURCE: GRDC)

- Highly competitive as early as two-leaf stage
- Produces up to 20,000 seeds/m<sup>2</sup> if uncontrolled
- About 40 percent of seed germinates at season break
- Another 10-30 percent germinates later in the season
- Seedbank can be depleted by 75 percent per year with good control
- Minimum tillage, narrow row spacings and banded fertiliser boost crop competition
- Seed catching at harvest is only partially effective
- In early harvested crops, up to 75 percent of seed is typically captured
- In late harvested crops, very few seeds are caught
- Harvesters can spread seed up to 250 metres from the parent plant
- Host for Cereal Cyst Nematode (*Heterodera avenae*) and the Root Lesion Nematode (RLN) *Pratylenchus neglectus*
- Poor host of RLN P. thorneii.26





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**Table 7:** Tactics that should be considered when developing an integrated plan to manage wild oats.<sup>27</sup>

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Wild oats (Avena spp.)		Most likely % control (range)	Comments on use
Agronomy	Crop choice and sequence	95 (30–99)	Summer crop—winter fallow rotation is very effective; numbers build up in winter pulse crops. Maintaining a clean winter fallow is the key to success.
Agronomy	Improve crop competition	70 (20–99)	Competitive crops at optimum sowing rates are very effective. High levels of control are achieved with barley, much lower with wheat.
Agronomy	Herbicide tolerant crops	90 (80–99)	Good to excellent control achieved with glyphosate resistant and triazine tolerant crops.
Tactic	Autumn tickle	40 (30–60)	Needs an early break to season. Combine with delayed sowing.
Tactic	Delayed sowing	40 (30-60)	Must be used with autumn tickle.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	80 (70–90)	Wait until youngest plants have 2 leaves if possible. Late germinations will not be controlled.
Tactic	Pre-emergent herbicides	80 (70–90)	Works best when combined with competitive crops.
Tactic	Selective post-emergent herbicides	80 (70–90)	Test for resistance before spraying. Use in combination with competitive crops.
Tactic	Spray-topping with selective herbicides	90 (60–99)	Flamprop methyl is very effective on flamprop susceptible wild oats. Best results with competitive crops, warmer conditions and at very early jointing stage of wild oats. Group Z resistance is common in many areas.
Tactic	Pasture spray-topping	80 (70–90)	Graze or spray survivors. Hay freezing works well.
Tactic	Silage and hay – crops and pastures	97 (95–99)	Harvest when wild oats are flowering. Control regrowth.
Tactic	Grazing – actively managing weeds in pastures	75 (60–80)	Graze heavily and continuously in spring.
Tactic	Weed seed collection at harvest	70 (20–80)	Works well on early harvested crops before wild oats drop their seeds.
Tactic	Sow weed-free seed	95 (0-100)	Only sow seed produced in wild oat-free paddocks.
Tactic	Clean farm machinery and vehicles	80 (0-100)	Ensure harvesters are well cleaned before moving to clean property or paddock.

(SOURCE: GRDC)28

- 27 GRDC (2016) Integrated Weed Management hub, weed profile 'Wild oats': <u>https://grdc.com.au/resources-and-publications/iwmhub/</u> common-weeds-of-cropping/wild-oats
- 28 GRDC (2016) Integrated Weed Management hub, weed profile 'Wild oats', <u>https://grdc.com.au/Resources/IWMhub/Section-8-Profiles-of-common-weeds-of-cropping/Wild-oats</u>





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It is advised to plant weed seed-free crop and pasture seed, use clean tillage and harvesting machinery and clean any imported hay/grain for livestock to keep paddocks clean.

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Controlling wild oats early in the season will help maximise lupin yields.

A knockdown herbicide, such as a full label rate of glyphosate, followed five to seven days later with a full label rate of paraquat and use of minimum tillage can set up lupin paddocks well.

Pre-emergent herbicides that can be used for wild oats in lupin crops in the southern region include simazine and some newer products – for suppression – and triallate (Group J).

Post-emergent selective herbicides registered to control wild oats in lupin crops are:

- » Fluazifop-P (Group A)
- » Butroxydim (Group A)
- » Haloxyfop (Group A)
- » Quizalofop (Group A).

Tips for post-emergent herbicide applications to control wild oats in lupin crops include:

- » On sandy soils use lower simazine rates (registered for suppression only)
- » Group A herbicides (fops and dims) usually provide best in-crop control
- » Repeated herbicide use may lead to resistance
- » Rotation with triallate + trifluralin can help delay resistance.29





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GRDC Integrated weed management hub 'Brome grass': <u>https://grdc.</u> <u>com.au/resources-and-publications/</u> <u>iwmhub/common-weeds-of-cropping/</u> <u>brome-grass</u>

DPIRD 'Brome Grass': https://www.agric.wa.gov.au/grainsresearch-development/managementbrome-grass-bromus-spp

HerbiGuide 'Brome Grass': www.herbiguide.com.au/ Descriptions/hg\_Great\_Brome.htm



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**Figure 10:** An illustration of fop and dim-resistant brome grass that has died-off when first sprayed, but recovered to produce new tillers. (SOURCE: GRDC)

- Widespread across southern Australia
- Highly competitive with crops
- More aggressive than annual ryegrass, barley grass or silver grass
- Tolerant to drought and phosphorus (P) deficiency
- Produces high numbers of seeds 600-3000 per plant
- Host for nematodes and cereal diseases
- Declining use of some Group A and B herbicides
- Resistance to Group A herbicides in one population in Victoria
- Most seeds shed before harvest, so HWSC not highly effective.<sup>30,31</sup>



<sup>30</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>

<sup>31</sup> GRDC (2014) Integrated Weed Management Manual: <u>www.grdc.com.au/IWMM</u>



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### Management and control of brome grass

 
 Table 8: Tactics that should be considered when developing an integrated plan to
 manage brome grass.<sup>32</sup>

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Brome grass (Bromus spp	5 5.)	Most likely % control (range)	Comments on use
Tactic	Burning residues	70 (60–80)	Sufficient crop residues are needed.
Tactic	Autumn tickle	50 (20–60)	Depends on seasonal break. Seed burial through shallow cultivation enhances seed depletion through germination, especially in <i>B. diandrus</i> with its shorter dormancy and faster germination.
Tactic	Delayed sowing	70 (30–90)	Best results with early seasonal break.
Tactic	Fallow	80 (70-90	Start the chemical fallow before weeds set seed (i.e. early spring).
Tactic	Knockdown non-selective herbicides for fallow and pre- sowing control	80 (30–99)	If possible delay spraying until full emergence and youngest plants have 2 leaves.
Tactic	Pre-emergent herbicides	80 (40–90)	Follow label directions, especially on incorporation requirements of some herbicides.
Tactic	Selective post- emergent herbicides	90 (75–99)	Apply when weeds have 2 to 6 leaves and are actively growing.
Tactic	Pasture spray- topping	75 (50–90)	Spray before viable seedset. Respray or graze survivors. Use this technique 2 years before going back to crop.
Tactic	Silage and hay – crops and pastures	60 (40–80)	Silage is better than hay. Graze or spray regrowth.
Tactic	Manuring, mulching and hay- freezing	90 (75-95)	Manuring works well if done before seed set. Any regrowth must be controlled.
Tactic	Grazing – actively managing weeds in pastures	50 (20–80)	Graze infested areas heavily and continuously in winter and spring.
Tactic	Weed seed collection at harvest	70 (10–75)	Works best on early harvested crops before weeds drop their seeds.



<sup>32</sup> GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, <u>www.grdc.com.au/GRDC-FS-PreHarvestHerbicide</u>



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Lupin crops can provide a better opportunity to control brome grass than cereal crops, as there are more herbicide options available.

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Preventing seed set later in the season with mowing, cultivation and/or burning windrows/paddocks can be effective in reducing the brome grass seedbank in the longer term.

Despite Australian Herbicide Resistance Initiative (AHRI) herbicide resistance surveys finding brome grass populations with resistance to some Group A, B and M herbicides, a range of pre and post-emergent options are still available to control this weed.

Crop-topping with glyphosate in lupin crops may also reduce brome grass seed set. Timing is the main issue to consider, as brome grass matures a lot faster than some crops and will set seed before the crop can be legally sprayed. Lupin crops typically mature early enough that desiccation is rarely warranted in some southern region areas.

Simazine can be used pre-emergence, but is registered for suppression only in the southern region.

Post-emergent herbicide options registered to control brome grass in southern region lupin crops include:

- » Clethodim (Group A)
- » Butroxydim (Group A)
- » Fluazifop (Group A)
- » Haloxyfop (Group A)
- » Quizalofop (Group A)
- » Propaquizafop (Group A).

## 5.5.4 Barley grass (*Hordeum glaucum* and *H. leporinum*).



**Figure 11:** Barley grass can be a source of stripe rust disease in grain cropping and pasture areas of the southern region.

(SOURCE: GRDC)

- Germinates rapidly in autumn
- Group A herbicides generally provide good control
- Other states have barley grass with resistance to paraquat and diquat; several Group A fops; and cross resistance to the Group A dim herbicides.<sup>33</sup>

#### 33 DPIRD (2016), Barley Grass, https://www.agric.wa.gov.au/grains-research-development/barley-grass



GRDC Integrated weed management hub 'Barley grass': <u>https://grdc.com.</u> <u>au/resources-and-publications/</u> <u>iwmhub/common-weeds-of-cropping/</u> <u>barley-grass</u>

DPIRD 'Barley Grass': <u>https://www.</u> agric.wa.gov.au/grains-research-<u>development/barley-grass</u>

Herbiguide, 'Barley Grass': http://www.herbiguide.com.au/ Descriptions/hg\_Barley\_Grass.htm





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### Management and control of barley grass

**Table 9:** Tactics that should be considered when developing an integrated plan to manage barley grass.  $^{\rm 34}$ 

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Barley grass (Hordeum s	; pp.)	Most likely % control (range)	Comments on use
Agronomy	Crop choice and sequence	85 (0-95)	Avoid planting barley in infested areas.
Agronomy	Herbicide tolerant crops	80 (40-95)	Triazines and imidazolinone herbicides provide useful control in triazine and imidazolinone tolerant crops respectively.
Tactic	Burning residues	50 (0–75)	Dropping chaff and straw into windrows improves control.
Tactic	Inversion ploughing	90 (70–99)	Use skimmers to ensure deep burial.
Tactic	Delayed sowing	60 (50–90)	Level of control depends on break.
Tactic	Fallow and pre- sowing cultivation	50 (30–80)	Requires dry weather following cultivation.
Tactic	Knockdown (non- selective) herbicides for fallow and pre- sowing control	80 (50–90)	Works best if delayed until the 2- to 4-leaf stage after good opening rains.
Tactic	Double knockdown or 'double-knock'	80 (60–95)	Works best if delayed until the 2- to 4-leaf stage after good opening rains.
Tactic	Pre emergent herbicides	85 (75–99)	Pyroxasulfone provides good control in wheat.
Tactic	Selective post- emergent herbicides	90 (80–95)	Several 'fop' herbicides provide good control in broadleaf crops. Sulfosulfuron provides suppression in wheat.
Tactic	Crop-topping with non-selective herbicide	80 (50–90)	Timing is aimed at maximising weed seed kill and minimising effect on the crop.
Tactic	Pasture spray- topping	60 (50–90)	Graze heavily or winter-clean with 'fop' herbicides to induce more uniform emergence of heads. Timing is critical. Graze or spray regrowth.
Tactic	Silage and hay – crops and pastures	50 (30–80)	Silage provides better control than hay making. Heavily graze or spray regrowth.
Tactic	Manuring – green and brown, mulching and hay freezing	75 (50–90)	Graze heavily to induce more uniform emergence of heads. Timing is critical. Graze or spray regrowth.
Tactic	Grazing – actively managing weeds in pastures	30 (0–50)	Use high stocking rates early in the season to reduce numbers, and late in the season to reduce seedset on infested paddocks.



34 GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, <u>www.grdc.com.au/GRDC-FS-PreHarvestHerbicide</u>



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Simazine can be used pre-emergence to control barley grass in southern region lupin crops and Sakura® can be used for supression.

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Post-emergent herbicide options to control barley grass in lupin crops in the southern region are:

- Clethodim (Group A)
- Butroxydim (Group A)
- Fluazifop (Group A)
- Haloxyfop (Group A)
- Quizalofop (Group A)
- Propaquizafop (Group A).

### 5.5.5 Silver Grass (Vulpia myuros and V. bromoides)



**Figure 12:** Silver grass can reduce lupin crop yields when at high densities. (SOURCE: Agronomo)

- Can severely reduce crop yields when at high densities
- A host for diseases and pests, including cereal root diseases, webworm
   and some RLN
- There are cases of paraquat resistance in some states
- Many herbicides provide suppression, rather than control
- Some herbicides only control surface germinating seeds (always check the label)
- Seed has little dormancy, making early control of the initial flush of germination highly effective.



GRDC Integrated weed management hub 'Silver grass': <u>https://grdc.com.</u> <u>au/resources-and-publications/</u> <u>iwmhub/common-weeds-of-cropping/</u> <u>vulpia</u>

DPIRD 'Silver Grass': <u>https://</u> www.agric.wa.gov.au/grainsresearch-development/silvergrass?page=0%2C1





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 Table 10:
 Tactics that should be considered when developing an integrated plan to manage silver grass.<sup>35</sup>

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Silver grass ( <i>Vulpia</i> spp.)		Most likely % control (range)	Comments on use
Agronomy	Crop choice and sequence	80 (70–95)	Rotate to a triazine tolerant or glyphosate resistant canola in heavily infested areas.
Agronomy	Herbicide tolerant crops	95 (90–99)	Using pre and post-emergent applications of triazine herbicide in triazine tolerant crops will almost eradicate most species of <i>Vulpia</i> .
Agronomy	Improve pasture competition	Variable	Reduces seed production, helping to maintain a low incidence of silver grass in a pasture. Winter clean with simazine.
Tactic	Burning residues	50 (30–70)	Use a hot fire back-burning into the wind.
Tactic	Inversion ploughing	90 (80–99)	Use a plough with skimmers to bury seed more than 75 mm deep.
Tactic	Autumn tickle	60 (50–80)	Requires an early break to the season. Combine with delayed sowing.
Tactic	Delayed sowing	75 (50–90)	Works well in most seasons. Tends to fail on non-wetting soils.
Tactic	Fallow and pre-sowing cultivation	70 (50–90)	Generally works well. Crop using full soil disturbance with late sowing to enable use of knockdown herbicides plus cultivation.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	Up to 95%	Ensure good herbicide coverage.
Tactic	Double knockdown or 'double-knock'	80 (70–95)	If this is required, pasture cleaning or spray-topping should have occurred 2 years before cropping.
Tactic	Pre emergent herbicides	80 (70–95)	Triazines are very good on most species of Vulpia.
Tactic	Selective post-emergent herbicides	Up to 95%	If silver grass is the main component of the pasture there will be a loss of winter fodder. The treated pasture should be resown in the following season or renovated to increase the component of desirable species.
Tactic	Pasture spray-topping	Up to 85%	Timing is critical. Heavy grazing leading up to topping will induce uniform head emergence. Gives the ability to keep desirable pasture species while reducing the incidence of silver grass. Conduct two seasons before cropping.
Tactic	Silage and hay – crops and pastures	Up to 90%	Cut for silage at commencement of flowering. Control regrowth.
Tactic	On-farm hygiene	Variable	Contaminated hay should not be moved to clean areas.



<sup>35</sup> Walsh, M, Aves, C, Powles, S (2014) Evaluation of harvest weed seed control systems, AHRI, Nineteenth Australasian Weeds Conference paper, 4 GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, <u>http://caws.org.au/awc/2014/awc201412881.pdf</u>



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### 5.6 Crop-topping for weed control

- Apply the non-selective herbicide paraquat prior to harvest
- Always check label for registration, rate and timing details
- Time application to target weeds at flowering and early grain fill
- This will minimise production of viable weed seed and crop yield loss
- Success requires sufficient gap in physiological maturity between crop and weed
- Ideal time is when 80 percent of lupin leaves have fallen off or turned brown
- Works best with early maturing lupin varieties.<sup>36</sup>

#### Management tips and tactics for crop-topping

In the southern region, paraquat is registered for crop-topping and can be applied at the 80 percent leaf drop point of the lupin crop. Crop-topping at this time has been shown to minimise lupin yield losses.<sup>37</sup>

Short season varieties, such as PBA Gunyidi<sup>()</sup>, Belara and Mandelup<sup>()</sup>, typically reach 80 percent leaf drop stage seven to 10 days earlier than longer season varieties and are well suited to crop-topping.

For annual ryegrass, crop-topping is most effective when the weed is at flowering to soft dough stage. If dough cannot be squeezed from the annual ryegrass seed, it will be viable even if crop-topping is used. In wet spring conditions, the duration of flowering and podding of the lupin crop can be extended due to the indeterminate growth habit of the crop. This prolongs the time until 80 percent leaf-drop in the crop and annual ryegrass can develop past the dough stage before the crop is ready. This highlights that crop-topping is a highly seasonally dependent tool that cannot be used each year unless lupin yield impact is accepted to ensure annual ryegrass is controlled.<sup>38</sup>



<sup>36</sup> GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, <u>www.grdc.com.au/GRDC-FS-PreHarvestHerbicide</u>

<sup>37</sup> GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, <u>www.grdc.com.au/GRDC-FS-PreHarvestHerbicide</u>

<sup>38</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.govau/cgi/viewcontent.cgi?article=1009&context=bulletins</u>



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WeedSmart 'HWSC Guide and Case Studies': <u>www.weedsmart.org.</u> au/wp-content/uploads/2013/12/ <u>AHRI-Harvest-Weed-Seed-Control-Booklet\_2013-version.pdf</u>



### 5.7 Harvest weed seed control (HWSC) tactics



**Figure 13:** The new integrated Harrington Seed Destructor (iHSD) system is one HWSC method that destroys weed seeds by pulverising the chaff fraction as it leaves the harvester.

(SOURCE: McIntosh & Son)

A major biological weakness of most cropping weeds of southern Australia is that their seed does not shatter before harvest, providing a good opportunity for removal at this time.

Capturing the weed seed and destroying it substantially reduces carry-over from the lupin crop into the next crop phase.

Common HWSC tactics include:

- » Collecting chaff in chaff carts
- » Burning or grazing chaff residue
- » Depositing chaff on narrow windrows for burning the next autumn
- » Using seed capture and destruction technology to pulverise and destroy chaff and weed seed fraction as it leaves the harvester
- » Diverting weed seeds onto permanent tramlines
- » Towing a baler behind the header to remove all harvest residue.

These HWSC systems remove both resistant and susceptible weed seeds that have survived earlier herbicide applications. This reduces the risk of herbicide resistance evolution and the selection pressure on herbicides.

Research at 25 sites across southern Australia during the 2010 and 2011 harvests found windrow burning, chaff cart and seed capture and destruction systems were equally effective at removing annual ryegrass seed from cropping paddocks. Each of these HWSC methods led to a 55 percent reduction in annual ryegrass germination the following year. Research has also shown that the seed capture and destruction systems consistently destroys 95 percent of annual ryegrass, wild radish, wild oats and brome grass seed present in the chaff fraction. Trials in WA have found chaff carts offer a reliable method of catching seed and are very effective at rapidly reducing large banks of weed seed.<sup>39</sup>



<sup>39</sup> Walsh, M, Aves, C, Powles, S (2014) Evaluation of harvest weed seed control systems, AHRI, Nineteenth Australasian Weeds Conference paper, 4 GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, <u>http://caws.org.au/awc/2014/awc201412881.pdf</u>



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Typically, 45 to 75 percent of annual ryegrass seed and 70 to 80 percent of wild radish seed is collected in a chaff cart. Baling behind the header can be a successful method to reduce weed seed banks. Trials have shown this can remove up to 98 percent of the weed seed that enters the header. But increased mineral nutrient input is required to budget for exported nutrients in the straw and a powerful header is required to tow the baler. To be viable, a market for the hay is needed – such as an export hay market or feed processing plant. Burning entire paddocks on sandplain soils needs to be carried out with extreme caution. This is generally undertaken very close to seeding, if at all. Burning lupin chaff that has been placed in a narrow windrow can be a more effective method than paddock burning to destroy annual ryegrass and radish seed. The burn kills almost all the seed in the windrow, but any burning needs to be balanced with the risks of erosion.<sup>40</sup>

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GRDC 'Summer Fallow Weed Management Guide': <u>www.grdc.com.au/GRDC-Manual-</u> SummerFallowWeedManagement

GRDC 'Hot Topic – Summer Fallow Weed Management': <u>www.grdc.com.</u> <u>au/Media-Centre/Hot-Topics/Summer-</u> fallow-weed-management

### 5.8 Summer weed control

- Conserves soil moisture and nutrients for crop use
- Reduces the need for high rates of herbicide knockdown before seeding
- Better controls large taproot species in knife point cultivation sowing systems
- Reduces risks of seeding delays
- Reduces weed allelopathic effects (such as toxin secretion) and can boost lupin emergence.<sup>41</sup>



Figure 14: Summer weeds are a scourge of WA lupin crops. (SOURCE: DPIRD)

The main summer weed species impacting on lupin crops in the southern region are:

- » Flaxleaf fleabane (Conyza bonariensis)
- » Windmill grass (Chloris truncata)
- » Feathertop Rhodes grass, or FTR (Chloris virgata)
- » Caltrop (Tribulus terrestris)
- » Skeleton weed (Chondrilla juncea)
- » Heliotrope (Heliotropium europaeum)
- » Afghan melon (Citrullus lantatus)
- » Paddy melon (Cucumis myriocarpus).

Growth rates of these weeds after summer rain are high and control in early stages of development is typically more reliable and cost effective than waiting until they are more robust.

Summer-growing weeds, especially melons, skeleton weed and heliotrope, are very effective at extracting water from the soil profile and this can rapidly remove crop yield benefits from summer rain.

Research has found weeds such as fleabane can only be adequately controlled in summer using a well-timed double-knock.



<sup>41</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>



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This is typically a full registered rate of glyphosate (Group M), followed by a full label rate of paraquat (Group L). But this adds pressure to spray all paddocks in a timely manner and increases weed control costs.

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Group B herbicides cannot be used for summer weed control on paddocks that will be sown to lupin crops, due to the re-cropping interval.<sup>42</sup>

It is also advised in low rainfall areas with low summer moisture to take a cautious approach to timing the use of 2,4-D amine (Group I) products during summer and before a lupin crop. Due to the residual nature of some Group I products in low-organic soils, these herbicides are often best to have rates reduced progressively after mid-December and alternatives found after mid-February. Plant back periods for these phenoxy (Group I) chemicals on sands with low organic matter can often be longer than the plant back periods provided on product labels. In some seasons and situations, there is not enough moisture in the topsoil of the sands for long enough to allow microbial breakdown of the herbicides.<sup>43</sup>

A light cultivation, or 'tickle', in autumn before sowing lupin crops can cover weed seeds with soil to provide good conditions for an early flush of germinating weeds. These can then be controlled with non-selective herbicides and cultivation during the seeding operation (if sowing after the break). An autumn tickle is most effective when the soil is moist for two weeks after cultivation and prior to the use of any knockdown herbicides.<sup>44</sup>



<sup>42</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <a href="http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins">http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</a>

<sup>43</sup> Cameron, J, Storrie, A (2014) Summer Fallow Weed Management – A reference manual for grain growers and advisers in the southern and western grains regions of Australia, GRDC, <u>www.grdc.com.au/GRDC-Manual-SummerFallowWeedManagement</u>

<sup>44</sup> White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins</u>


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5.9 Decision support tools

Adoption of successful IWM involves complex interactions, multiple year timeframes, many possible interventions, major environmental influences and high levels of uncertainty.

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The use of computer-based models can be a valuable tool to aid decision making.

Developed by AHRI, with GRDC investments, the Ryegrass Integrated Management (RIM) model evaluates the long term profitability of annual ryegrass control methods and reducing the weed seedbank.

Weed Seed Wizard is a simulation tool, developed in a national collaboration, which uses paddock management information to predict weed emergence and crop losses now and in the future to help growers devise effective IWM plans.

#### 5.9.1 Ryegrass Integrated Management (RIM)

RIM enables users to assess the effectiveness and budget implications of 10-year cropping and weed management scenarios using up-to-date economic parameters.

It has options for four crops, including lupin, three pastures and 43 practices that include herbicide use and rates, timing of application, soil preparation, crop type, grazing and HWSC options.

Graphs can be produced and exported to other software programs for analysing annual ryegrass survivors, gross margins across 10 years, yield loss from competition and ryegrass seedbank levels. See the link to this resource in the 'More information' box.

#### 5.9.2 Weed Seed Wizard

This model can investigate the impact of a wide range of IWM strategies (such as HWSC, increased crop competition, rotation change and various weed seed set controls such as crop-topping and hay making) on weed and weed seed numbers.

It was developed by DPIRD in partnership with The University of Western Australia, University of Adelaide, the New South Wales Department of Primary Industries and the Department of Agriculture Fisheries and Forestry in Queensland, with investments by GRDC.

The user enters site-specific weather data and soil type, the weed species to be investigated and information about past and future weed management.

The model uses real weather data and gives an estimate of crop yield loss as a result of weed pressure from a range of species. See the link to this resource in the 'More information' box.



Ryegrass Integrated Management 'User Guide and Video Tutorials': <u>http://ahri.uwa.edu.au/research/rim/</u> rim-videos-tutorials-and-examples/

### i) MORE INFORMATION

DPIRD 'Weed Seed Wizard': https://www.agric.wa.gov.au/weedseed-wizard/weed-seed-wizarddownload-and-help





### i) MORE INFORMATION

IPM 'Guidelines for Grains – Lupins': http://ipmguidelinesforgrains.com.au/ crops/winter-pulses/lupins/

CSIRO 'Insect Identification Resources Online': <u>http://www.csiro.</u> <u>au/en/Research/Collections/ANIC/</u> <u>ID-Resources</u>

CropLife Australia 'Resistance Management': <u>http://www.croplife.</u> org.au/industry-stewardship/ resistance-management/

GRDC 'Ground Cover Supplement – Pest Resistance Drives Need for IPM': <u>https://grdc.com.au/Media-</u> <u>Centre/Ground-Cover-Supplements/</u> <u>Ground-Cover-issue-94-SepOct-2011-</u> <u>Crop-Protection-Supplement/Pest-</u> <u>resistance-drives-need-for-IPM</u>

cesar 'PestFacts Map': <u>http://www.</u> cesaraustralia.com/sustainableagriculture/pestfacts-south-eastern/ pestfacts-map/

GRDC 'Crop Pest Management for Farming Systems in High Rainfall Areas of Southern Australia': <u>https://</u> <u>grdc.com.au/research/reports/</u> <u>report?id=1014</u>

# **Pests and insects**

#### 6.1 Overview

Lupin crops are more prone to insect and allied pest damage than cereal crops and need to be checked and monitored at critical stages of development.

These stages are: crop emergence and for three weeks after sowing; during flowering; and during pod fill.

#### 6.2 Integrated Pest Management (IPM) planning

An Integrated Pest Management (IPM) plan is recommended for southern region rotational cropping systems that include lupin.

It is advised that IPM practices include the following considerations:

- » Crop rotations some rotations can support pest presence (long-term pasture paddocks are more susceptible to many pests).
- » Soil preparation summer and autumn cultivation or herbicide use can eliminate pest feed sources.
- » Sowing time time planting windows when there is less likelihood of pest presence during critical crop development phases.
- » Crop establishment uniform crop establishment can assist crops withstand pest attack, as will appropriately treated seed.
- » Crop choice and variety varieties with disease and pest resistance are preferable, particularly those with seedling vigour and physiological features (such as hard seed coats) that deter pests.
- » Weed management some insects use weeds as host plants and weed control should be considered for adjacent paddocks, borders and roadsides – as well as in-crop control.
- » Disease management insects can be disease transmitters and damage exposes crops to infestations. Diseased plants are less competitive under insect attack.
- » Hygiene and sanitation machinery, vehicles and people can carry insects and it is important to minimise pest movement.
- » Insecticide use consider exposure of surrounding wildlife and beneficial insects.
- » Environmental conditions some weather, such as heavy rain, can affect the presence of insects on plants and reduce the need for insecticide use.
- » Beneficial insect preservation.





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IPM Guidelines 'Growing a Healthy Crop': <u>http://ipmguidelinesforgrains.</u> <u>com.au/ipm-information/growing-a-healthy-crop/</u>

IPM Guidelines 'Lupins': <u>http://</u> ipmguidelinesforgrains.com.au/crops/ winter-pulses/lupins/

CropLife Australia 'Resistance Management': <u>http://www.croplife.</u> org.au/industry-stewardship/ resistance-management/

GRDC 'Ground Cover Supplement – Pest Resistance Drives Need for IPM': <u>https://grdc.com.au/Media-</u> <u>Centre/Ground-Cover-Supplements/</u> <u>Ground-Cover-issue-94-SepOct-2011-</u> <u>Crop-Protection-Supplement/Pest-</u> <u>resistance-drives-need-for-IPM</u>

### (i) MORE INFORMATION

GRDC 'The Current and Potential Costs of Invertebrate Pests in Grain Crops': <u>https://grdc.com.</u> <u>au/resources-and-publications/</u> <u>all-publications/bookshop/2013/02/</u> <u>the-current-and-potential-costs-of-</u> <u>invertebrate-pests-in-grain-crops</u> Economic damage from insects and pests can occur in lupin crops during all crop growth phases.

Typically, the lupin plant can compensate for moderate damage that occurs early in development by setting new buds and pods to replace those lost. But excessive early damage can reduce yields and potentially delay harvest.

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Considering other control options for a lupin crop when planning insecticide use and crop rotations can help to reduce the risk of insecticide resistance.

Research is finding an over-reliance on broad-spectrum insecticides and pesticides, such as synthetic pyrethroids (SPs), is resulting in development of resistance in pests such as Green peach aphid, or GPA (*Myzus persicae*) and Redlegged earth mites, or RLEM (*Halotydeus destructor*).

Researchers advise that more strategic pest management is required to control resistant populations and minimise the risk of resistance developing further.

They are carrying out research to map insecticide and pesticide resistance in crop pests and insects across Australia, along with further development and promotion of IPM practices.

The basic IPM strategy for all legumes, including lupin, is to avoid non-selective insecticides for as long as possible in order to foster a build-up of predators and parasites (the industry message is to: 'Go soft early').

This helps to keep early pests, such as aphids (*Aphididae*) in check – as predators can stop populations from building up.

However, intervention may be required during podding, especially against native budworm (*Helicoverpa punctigera*) and aphid populations, which can peak during late pod fill.

#### 6.3 Costs of insect and pest control

A 2013 report studied the costs of controlling major grain crop insect pests nationally.

It found that, while action thresholds drive treatment for most pests, very few of these have been derived from empirical (direct observation and experience) analysis.<sup>1</sup>

There was evidence to suggest a move away from tillage towards minimum or no-till farming systems and a changing climate had altered the status of invertebrate pests in the Australian grains industry.

In the southern region, snails represent the biggest current and potential threat to yield in all crops followed by balaustium mite (*Balaustium medicagoense*).<sup>2</sup>



<sup>1</sup> Murray, Dave, Clarke, Michael, Ronning, David (2013) GRDC, The current and potential costs of invertebrate pests in grain crops, https://grdc.com.au/resources-and-publications/all-publications/bookshop/2013/02/the-current-and-potential-costs-of-invertebratepests-in-arain-crops

<sup>2</sup> Murray, Dave, Clarke, Michael, Ronning, David (2013) GRDC, The current and potential costs of invertebrate pests in grain crops, https://grdc.com.au/resources-and-publications/all-publications/bookshop/2013/02/the-current-and-potential-costs-of-invertebratepests-in-grain-crops



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 Table 1: The potential costs of invertebrate pests in grain crops.<sup>3</sup>

Invertebrate pest	Representative	Active ingredient	Chemical
• "	pesticide control		cost per na
Snails			
Snails (various)	baits	metaldehyde	\$12.00
Mites			
Redlegged earth mite	PSPE	bifenthrin	\$1.60
Blue oat mite	PSPE	bifenthrin	\$1.60
Bryobia (various) / Balaustium mite	pre-sowing and knockdown	omethoate	\$1.90
Springtails			
Lucerne flea	PSPE	omethoate	\$1.90
Aphids			
Aphids (various)	dimethoate	dimethoate	\$6.25
Caterpillars			
Etiella moth	SP	alpha-cypermethrin	\$2.55
Budworms	SP	alpha-cypermethrin	\$2.55
Cutworms (various)	SP	alpha-cypermethrin	\$0.64
Weed web moth	SP	alpha-cypermethrin	\$2.55
Beetles			
Weevils (various)	SP	alpha-cypermethrin	\$0.85
Earwigs			
European earwigs	no treatment*		

Additional Pests (N/A)

PSPE: post sowing pre-emergent, SP: Synthetic pyrethroid \* Controls may be permitted under relevant State Pesticide Regulations



3 Murray, Dave, Clarke, Michael, Ronning, David (2013) GRDC, The current and potential costs of invertebrate pests in grain crops, https://grdc.com.au/resources-and-publications/all-publications/bookshop/2013/02/the-current-and-potential-costs-of-invertebratepests-in-grain-crops



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GRDC 'Fact Sheet – Snail Management': <u>https://grdc.com.au/</u> <u>Resources/Factsheets/2012/09/Snail-</u> <u>Management</u>

DPIRD 'Identification and Control of Pest Slugs and Snails for Broadacre Crops in Western Australia': <u>https://www.agric.wa.gov.au/grains/</u> <u>identification-and-control-pest-slugs-</u> <u>and-snails-broadacre-crops-western-</u> <u>australia?nopaging=1</u>

IPM Guidelines 'Slugs and Snails': http://ipmguidelinesforgrains.com.au/ pests/slugs-and-snails/

Pest Notes Southern 'Vineyard Snail': http://pir.sa.gov.au/\_\_data/assets/ pdf\_file/0016/273004/Vinyard\_snail. pdf/

Pest Notes Southern 'White Italian Snail': <u>http://pir.sa.gov.au/\_\_data/</u> <u>assets/pdf\_file/0018/273006/White\_</u> <u>Italian\_snail.pdf</u>

Pest Notes Southern 'Small Pointed Snail': <u>http://pir.sa.gov.au/\_\_data/</u> <u>assets/pdf\_file/0011/272990/Conical\_</u> <u>or\_pointed\_snail.pdf</u>



#### 6.4 Pest identification and management

In the southern region, there are many invertebrate pests that can cause damage to lupin crops.

The major pests of economic importance include:

- » Snails
- » RLEM
- » Blue oat mites (Penthaleus major)
- » Balaustium mites
- » Lucerne flea (Sminthurus viridis)
- » Aphids
- » Lucerne seed web moth (Etiella behrii)
- » Native budworm
- » Cutworms (Dasygaster discoideus)
- » Weed web moth (Achrya affinitalis)
- » Grey-banded leaf weevil (Ethemaia sellata)
- » European earwig (Forficula auricularia).

Most lupin crop pests can be controlled with appropriate insecticides, but resistance management should be carefully considered. Registered insecticides for pests of lupin crops are outlined in more detail in this chapter. It is advised to always check label actives and rates before use.

Some pests are better controlled using crop rotations, or other cultural means, as there may be no insecticide options available for use in lupin crops in the southern region.

#### 6.4.1 Snails

There are several snail species that prey on lupin crops in the southern region. The main ones are:

Figure 1: Conical or small pointed snail (Cochlicella barbara) on canola













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(SOURCE: GRDC)



Figure 3: Vineyard or common white snail (Cernuella virgata)

(SOURCE: GRDC)

Typical signs of snail presence in lupin crops include irregular pieces chewed from leaves and shredded leaf edges.

Cereal crops are likely to survive damage by slugs and snails, but canola and lupin typically cannot compensate for the damage or loss of cotyledons.

The rule of thumb is to monitor snail numbers on a regular basis and implement control prior to seeding. Baiting is the only option after the crop has been sown and germination has started.





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Monitoring of snails in lupin crops involves:

 » January/February – assess stubble management options for slug and snail management (including rolling or chaining paddocks to get snails to fall to the ground)

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- » March/April assess options for burning and/or baiting
- » May to August assess options for baiting, especially along fence lines
- Three to four weeks before harvest assess risk of snail contamination of grain and, if required, implement management tactics.

Control options should be considered when certain thresholds are met, as detailed in Table 2.

Species	Oilseeds	Cereals	Pulses	Pastures
Black keeled slug	1-2/m <sup>2</sup>	1-2/m <sup>2</sup>	1-2/m <sup>2</sup>	5/m <sup>2</sup>
Reticulated slug	1-2/m <sup>2</sup>	5/m <sup>2</sup>	1-2/m <sup>2</sup>	5/m <sup>2</sup>
Small pointed snail	20/m <sup>2</sup>	40/m <sup>2</sup>	5 per seedling	100/m <sup>2</sup>
Vineyard snail	5/m <sup>2</sup>	20/m <sup>2</sup>	5/m <sup>2</sup>	80/m <sup>2</sup>
White Italian snail	5/m <sup>2</sup>	20/m <sup>2</sup>	5/m <sup>2</sup>	80/m <sup>2</sup>

Table 2: Suggested thresholds for control of slugs and snails in broadacre crops.<sup>4</sup>

Please note: the above thresholds are from limited data. It is essential to carefully monitor crops as distributions of snails and slugs are patchy. (SOURCE: DPIRD)

Pre-seeding management can help control snails in many areas.

An even burn of crop residues has been shown to achieve an 80-100 percent kill, but wind and water erosion risks should be carefully considered. Grazing stubbles during summer reduces ground cover and removes snail refuge areas. At seeding, the use of equipment with wide points, or full-cut discs to 5 centimetres, has been found to reduce snail numbers by up to 60 percent.<sup>5</sup>

Rolling or chaining paddocks can crush snails or knock them off stubble/plant material and on to the ground where there is little protection from heat. Rolling with a rubber or steel roller can crush a small percentage or snails, but eliminating elevated material – such as stubble – where snails aestivate and escape the heat is key to success.

Baits are a chemical control option for snails, but are only suitable for snails larger than seven millimetres in diameter. There is an associated kill rate of about 50 percent when bait is applied at a rate of five kilograms per hectare.<sup>6</sup>

Baiting can be more effective when carried out after rain in autumn, when snails are known to descend from the stubble or posts, begin to forage, mate and lay eggs.

Summer weed spraying and fence line weed control can assist in snail management.

5 DPIRD website (2016) Identification and control of pest slugs and snails for broadacre crops in Western Australia, www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia



<sup>4</sup> DPIRD website (2016) Identification and control of pest slugs and snails for broadacre crops in Western Australia, www.aqric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia

<sup>6</sup> DPIRD website (2016) Identification and control of pest slugs and snails for broadacre crops in Western Australia, www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia



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Department of Agriculture Victoria 'Redlegged Earth Mite': http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/ pest-insects-and-mites/redleggedearth-mite

cesar 'Redlegged Earth Mite': http://www.cesaraustralia.com/ sustainable-agriculture/pestnotes/ insect/Redlegged-earth-mite

DPIRD 'Diagnosing Redlegged Earth Mite': <u>https://www.agric.wa.gov.au/</u> <u>mycrop/diagnosing-redlegged-earth-</u> <u>mite</u>

**cesar** 'RLEM Resistance Testing Service': email jmaino@cesaraustralia.com



**Figure 4:** *Redlegged earth mites are a serious pest of lupin crops.* (SOURCE: DPIRD)

Canola and pulse crops, including lupin, are most susceptible to Redlegged earth mite (RLEM) damage.

These mites also feed on broadleaf weeds in groups of about 30 and are most active between April and November in southern Australia.

The RLEM is called an 'earth' mite because it spends 90 percent of its time on the soil surface, rather than on the foliage of plants.

The mites feed on foliage for short periods and then move around to settle at the next feeding site.

When in high numbers, these pests are particularly damaging to seedlings of lupin, other legumes and oilseeds.

Monitoring of RLEM in lupin crops involves:

- » Inspecting crops in autumn-spring for presence and damage
- » Inspecting crops in the first three to five weeks after sowing
- » Detecting in the morning or on overcast days
- » Consider control if plants are not outgrowing damage.



Figure 5: Map showing occurrence of Redlegged earth mite. (SOURCE: P. Umina, cesar)



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Early sown lupin crops have the best chance of getting away before populations of RLEM increase to damaging levels.

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It is typically only necessary to treat RLEM with foliar insecticide if lupin seedlings are being attacked and damaged at emergence and cannot grow away from the damage.

Lupin seed can be treated with systemic insecticides to protect seedlings and contact insecticides can be used if severe attacks occur as plants emerge.

TimeRite<sup>®</sup> is an industry-developed management package that can be used for planning RLEM control in the spring (during a pasture phase) the year before lupin crops are sown.

RLEM with resistance to synthetic pyrethroids (SPs) have been detected by researchers in Australia and this is a risk for all southern region growers.

Management for resistance includes rotating insecticide actives in and between seasons.

Growers and advisers in the southern cropping region can access a testing service to determine whether RLEM populations in their paddocks are resistant to insecticides.

Knowing the resistance status of RLEM populations will assist in implementing appropriate and effective insect management strategies.

The RLEM insecticide-resistance testing service is being made available through a national project with GRDC investment led by the University of Melbourne in collaboration with **cesar**, CSIRO and Department of Primary Industries and Regional Development (DPIRD).

Any grower or adviser experiencing a chemical control failure involving RLEM, or suspecting issues with insecticide resistance, is encouraged to contact **cesar** and have specimens tested.

For low-moderate mite populations, insecticide seed dressings are an effective method of control. It is recommended to avoid prophylactic sprays and to apply insecticides only if control is warranted.<sup>7</sup>

Insecticides used at or after sowing should be applied within three weeks of the first appearance of mites, before adults start laying eggs. Insecticides do not kill mite eggs. Border spraying can be an effective way to control mites.

Pre and post-sowing weed management, particularly of broadleaf species, is vital when growing lupins.  $^{\rm 8}$ 

Non-chemical control options include grazing with livestock during summer or sowing non-susceptible crops in the rotation.

Approved insecticides for the control of RLEM in lupin crops in the southern region include:

- » Beta-cyfluthrin (active approved, but no registered products are available)
- » Lambdacyhalothrin
- » Gamma-cyhalothrin
- » Alpha-cypermethrin
- » Methidathion
- » Omethoate
- Dimethoate.



<sup>7</sup> DPIRD website (2016) Diagnosing redlegged earth mite, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-redlegged-earth-mite</u>

<sup>8</sup> DPIRD website (2016) Diagnosing redlegged earth mite, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-redlegged-earth-mite</u>



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### (i) MORE INFORMATION

DPIRD 'Diagnosing Blue Oat Mite': https://www.agric.wa.gov.au/mycrop/ diagnosing-blue-oat-mite

Pest Notes Southern 'Blue Oat Mite': http://www.herbiguide.com.au/ Descriptions/hg\_Blue\_Oat\_Mite.htm

Queensland Department of Agriculture 'Blue Oat Mite': <u>https://www.daf.qld.gov.au/</u> plants/field-crops-and-pastures/ broadacre-field-crops/integratedpest-management/a-z-insect-pest-list/ mites-overview/blue-oat-mite



#### 6.4.3 Blue oat mite (Penthaleus major)



**Figure 6:** Blue oat mite are dark purple or blue with a red spot and can cause discoloration of crop leaves.

(SOURCE: Andrew Weeks, cesar)

All crops, including lupin, are vulnerable to blue oat mite damage, particularly at the seedling stage.

Blue oat mites can be confused with RLEM, as they are dark purple/blue with a red spot on the back and eight orange legs.

Feeding by these pests on crops causes a silver or white discolouration of leaves and possible distortion or shrivelling if damage is severe.

Seedlings under stress from factors such as cold, waterlogging or dry conditions are more susceptible to damage.

To prevent population build up, insecticides should be applied within three weeks of the first appearance of mites before adults start laying eggs.

When monitoring for blue oat mite, consider these insects are active in winter and spring after hatching in autumn from summer laid eggs.

Mites are most easily seen in the late afternoon when they start feeding on leaves. Check from planting to early vegetative stage, particularly in dry seasons.

Blue oat mites have higher natural tolerance to a range of insecticides. The approved insecticide for control of blue oat mites in NSW (and WA) is chlorpyrifos.

Ensure sprays are applied at registered rates.

All currently registered insecticides are only effective when mites are at active stages.

For low-moderate mite populations, insecticide seed dressings are an effective option.

It is advised to avoid prophylactic sprays and apply insecticides only if control is warranted and mites are positively identified.

Insecticides used at or after sowing are best applied within three weeks of the first appearance of mites, before adults start laying eggs.

Foliar applications of insecticides may be cost-effective if applied within two or three weeks of emergence in autumn. The use of control tactics solely in spring will not prevent the carry-over of eggs into the following autumn.





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### (i) MORE INFORMATION

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Agriculture Victoria 'Balaustium Mite': <u>http://agriculture.vic.gov.au/</u> <u>agriculture/pests-diseases-and-</u> <u>weeds/pest-insects-and-mites/</u> <u>balaustium-mite</u>

DPIRD 'Diagnosing balaustium mite': https://www.agric.wa.gov.au/mycrop/ diagnosing-balaustium-mite

HerbiGuide 'Balaustium Mite': http://www.herbiguide.com.au/ Descriptions/hg\_Balaustium\_Mite.htm



6.4.4 Balaustium mites (*Balaustium medicagoense*)



**Figure 7:** The balaustium mite adult reaches about 2 mm in length, with a rounded dark red-brown body and red legs with distinct short hairs on the body.

This emerging pest of the grains industry can be confused with other mites, but grows much bigger.

The adult reaches about 2 mm in length, with a rounded dark red-brown body and red legs with distinct short hairs on the body.

These insects are found across most agricultural regions in southern Australia, but are generally restricted to coastal areas.

They do not tend to be found too far inland or in the drier Mallee areas of Victoria and South Australia.

Balaustium mites can cause the cotyledons and leaves of lupin plants to have a leathery and silvered appearance. High numbers of the mites can give a bleached appearance.

Lupin crops can usually grow beyond the damage from these mites.

This insect is a concern in lupin in the southern region but the mites generally prefer feeding on grasses, cereals and weeds.

It is recommended to closely inspect susceptible pastures and crops from autumn to spring for the presence of mites and evidence of crop damage.

It is vital to monitor crops regularly in the first three to five weeks after sowing.

Lupin crops sown into paddocks that were grown to pasture the previous year should be regularly inspected for balaustium mites.

Weeds present in paddocks prior to cropping should also be checked for the presence and abundance of balaustium mites.

There is currently no chemical control registered in Australia for balaustium mite.

Alternative methods for control can be effective, such as removing summer weeds in and around paddocks. This mite particularly thrives when capeweed and grasses are present.

Crop rotation can also assist with control, by rotating susceptible crops such as cereals, lupins or canola, with a broadleaf plant such as vetch.





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### i) MORE INFORMATION

Agriculture Victoria 'Lucerne Flea': <u>http://agriculture.vic.gov.au/</u> <u>agriculture/pests-diseases-and-</u> <u>weeds/pest-insects-and-mites/</u> <u>lucerne-flea</u>

DPIRD 'Diagnosing Lucerne Flea': https://www.agric.wa.gov.au/mycrop/ diagnosing-lucerne-flea

IPM Guidelines 'Lucerne Flea': http://ipmguidelinesforgrains.com.au/ pests/lucerne-flea-in-winter-seedlingcrops/

cesar 'Lucerne Flea': <u>http://www.</u> <u>cesaraustralia.com/sustainable-</u> <u>agriculture/pestnotes/insect/Lucerne-</u> <u>flea</u>





**Figure 8:** Lucerne flea typically moves up the lupin plant from ground level, eating tissue from the underside of foliage.

(SOURCE: Andrew Weeks, cesar)

Lucerne flea is a green-yellow insect that has a furcula underneath its abdomen, which can be used to spring off vegetation when disturbed.

It is commonly found in South Australia and Victoria and is generally more problematic on loam/clay soils.

Lucerne flea pests are often sporadically distributed in paddocks and across a region.

The insect moves up the lupin plant from ground level, eating tissue from the underside of foliage.

It feeds through a rasping process, leaving behind a thin clear layer of leaf membrane that appears as transparent 'windows' through the leaf.

In severe infestations, this damage can skeletonise the leaf and stunt or kill plant seedlings.

Crops and pastures are most susceptible at the time of emergence.

The first soaking rains at the start of the growing season cause the over-summering eggs of lucerne fleas to hatch.

Several generations may develop during the growing season, depending on the weather. At the onset of warmer and drier conditions in spring, over-summering eggs are produced.

This pest is more common on heavier soils and rarely present on very sandy soils with low clay content.

SPs should be avoided for the control of lucerne fleas. Grazing management, border sprays or spot spraying can be sufficient to control populations.

Lupin crops are most likely to be damaged by lucerne fleas if planted in a paddock that grew a weed infested crop or a pasture in which lucerne fleas were not controlled during the previous spring.

Insecticides that control mites do not necessarily control lucerne flea.



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Approved insecticides for control of lucerne fleas in lupins in the southern region include:

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- » Omethoate
- » Methidathion
- » Imidacloprid
- » Dimethoate
- » Chlorpyrifos.

#### 6.4.6 Aphids (Aphididae)



**Figure 9:** Aphids are a pest of lupin crops at the flowering stage. (SOURCE: GRDC)

Three main types of aphids can appear in southern region lupin crops during the flowering stage of growth. These are cowpea aphids (*Aphis craccivora*), Blue green aphids (*Acyrthosiphon kondoi*) and Green peach aphids (*Myzus persicae*).

Cowpea aphids are charcoal grey-shiny black and colonise single plants or groups in a 'hot spot' in the crop.

Blue green aphids are the same colour as lupin leaves and distribute evenly throughout the crop, but can congregate on some plants in larger population sizes.

Green peach aphids are pale green, similar to the lupin stem, and are usually found on the underside of older leaves. These usually cause less feeding damage than other aphid species.

Aphids cause the bulk of damage to lupin crops before plant symptoms are obvious. Typically, by the time symptoms are visible, yield loss that cannot be recovered by insecticide control will have occurred.

Winged aphids fly into lupin crops from surrounding vegetation and pastures.

Spring population size depends on autumn and winter conditions.

Long autumn growing periods allow early build-up and spread of aphids.

Mild (not cold) winters allow further development and spread of winged aphids, which can establish many small colonies across a crop.

Some lupin varieties are more susceptible to aphid feeding damage than others.

Aphids transmit two significant viruses in lupin: Cucumber mosaic virus (CMV) and Bean yellow mosaic virus (BYMV). More information about these diseases is outlined in Chapter 8.



DPIRD 'Identification of Aphids in Lupin Crops': <u>https://www.</u> agric.wa.gov.au/grains-researchdevelopment/identification-aphidslupin-crops

IPM Guidelines 'Aphids in Pulses': http://ipmguidelinesforgrains.com.au/ pests/aphids/aphids-in-pulses/





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The threshold for aphid control with insecticide to produce a yield response in lupin crops is typically when 30 percent of flowering buds have more than 30 aphids.<sup>9</sup>

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The best method to estimate numbers is to check at several points in the paddock and inspect flowering heads at random.

When deciding on control measures, it is advised to consider any other beneficial insects, such as hover flies, ladybirds, lacewings and parasitic wasps that attack aphids and keep populations low.

It is recommended to use targeted aphid insecticides only and leave beneficial insects unharmed.

Other aphid management strategies for lupin crops include:

- » High seeding rates to generate dense crop stands
- » Cereal barriers around the crop
- » Heavy grazing of adjoining pasture paddocks to reduce aphid numbers
- » Strategic aphicide/insecticide sprays.

Some aphid populations are resistant to pirimicarb, SPs and organophosphates (OPs). The level of resistance to OPs appears to have plateaued in southern Australia in recent years.

Populations of GPA were found to be resistant to neonicotinoid insecticides (commonly used in seed treatments) for the first time in Australia in late 2016.

Approved insecticides for control of aphids in the southern region include:

#### Cowpea aphid

Methidathion (SA only)

Dimethoate.

#### Blue green aphid

Dimethoate.

#### Green peach aphid

Pirimicarb

Petroleum Oil

Paraffinic Oil (suppression only in some states, check label)

Dimethoate.

#### 6.4.7 Lucerne seed web moth (Etiella behrii)

Lucerne seed web moths are grey brown with a stripe on each forewing and an orange band across the wing base.

This pest is widespread throughout Australia and a serious problem in SA and VIC.

Lucerne seed web moths produce three to four generations each year in spring, summer and autumn.

Newly hatched larvae feed on the seed in lupin crop pods.

The damaged seeds have jagged edges similar to native budworm damage, but are distinguished by the presence of webbing in the pod.

In most seasons, this pest causes little damage to seed.

It is typically only in years when numbers are high that significant yield losses have been reported. But unless the crop is carefully monitored at regular intervals, considerable damage may occur.



i MORE INFORMATION

IPM guidelines 'Etiella': http://ipmguidelinesforgrains.com.au/ pests/etiella/

cesar 'Lucerne Seed Web Moth or Etiella': <u>http://www.cesaraustralia.</u> com/sustainable-agriculture/ pestnotes/insect/Lucerne-seed-webmoth-or-Etiella





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### (i) MORE INFORMATION

DPIRD 'Diagnosing Native Budworm in Narrow-leafed Lupins': <u>https://</u> <u>www.agric.wa.gov.au/mycrop/</u> <u>diagnosing-native-budworm-narrow-</u> <u>leafed-lupins</u>

DPIRD 'Management and Economic Thresholds for Native Budworm: <u>https://www.agric.</u> wa.gov.au/grains/managementand-economic-thresholds-nativebudworm?page=0%2C4#smartpag ing\_toc\_p4\_s1\_h3

Pest Notes Southern 'Native Budworm': <u>http://www.pir.</u> <u>sa.gov.au/\_\_data/assets/pdf\_</u> <u>file/0005/274181/Native\_Budworm.</u> <u>pdf</u>

IPM Guidelines 'Native Budworm in Winter Pulses': <u>http://</u> ipmguidelinesforgrains.com.au/pests/ helicoverpa/native-budworm-inwinter-pulses/

Pulse Australia Southern 'Pulse Bulletin, Managing Native Budworm in Pulse Crops: <u>http://www.pulseaus.</u> <u>com.au/storage/app/media/</u> <u>crops/2010\_SPB-Pulses-native-</u> <u>budworm.pdf</u>

Agriculture Victoria 'Native Budworm': http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pestinsects-and-mites/native-budworm There are several insecticides registered for use on lucerne seed web moth and it is advisable to carefully check labels for use in lupin crops in each State. Insecticides should be considered when moth activity is first observed in lupin crops.

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When eggs have been laid and larvae have bored into seed pods, insecticide applications are mostly ineffective as the larvae are protected from sprays.

Time of sowing and variety selection (choosing early maturing lines) can result in crops flowering and setting pods prior to peak activity of lucerne seed web moths.

The risk period is when pods are green. Dry pods are not at risk.

#### 6.4.8 Native budworm (Helicoverpa punctigera)



**Figure 10:** The larvae of native budworm are shades of orange, brown and green with dark stripes on the body.

(SOURCE: SARDI)

Budworm can develop big populations on native plants and then migrate into agricultural areas in late winter and spring.

The larvae are shades of orange, brown and green with dark stripes on the body.

Adult moths are about 15-18 mm in length and a buff, light brown to red-brown colour, with numerous dark spots and blotches.

The hind wings of the adult moth are pale, with a dark band along the lower edge, and span 30-35 mm.

Caterpillars feed on leaves and stems until the crop nears maturity, when they are attracted to the pods. These insect pests drill through the pod wall and eat the seeds.

Pod walls are not penetrated until the caterpillars are more than 15 mm in length.

Damage to narrow leafed lupin typically occurs when plants are close to maturity and the pods are losing their green colour. Symptoms include chewing to leaves, flowers and pods.

A decision to treat a lupin crop for budworm should not be made until damage is about to occur and the pods are beginning to mature.

Natural mortality of budworm populations is sometimes sufficient to prevent economic damage.

It is best practice to sample the crop to estimate the number of caterpillars present. If possible, use a sweep net.





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The number of caterpillars caught in 10 sweeps of a sweep net is equivalent to about the number in one square metre of crop.

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At least five lots of 10 sweeps are needed in several parts of the crop for an adequate sample.  $^{\mbox{\tiny 10}}$ 

Approved insecticides for control of budworm in lupin crops in the southern region include:

- » Zeta-cypermethrin (SA only)
- » Spinetoram
- » Nuclear Polyhedrosis virus of helicoverpa armigera
- » Methomyl
- » Lambda-cyhalothrin
- » Esfenvalerate
- » Deltamethrin
- » Cypermethrin
- » Beta-cypermethrin
- » Bacillus thuringiensis subsp kurkstaki strain HD-1
- » Alpha-cypermethrin.

#### 6.4.9 Cutworms (Agrotis spp.)



**Figure 11:** Larvae of cutworms can feed on young plants and stems at or below the soil surface and often cut off entire plants.

(SOURCE: SARDI)

These pests feed on all crop and pasture plants, including lupin, causing damage near to the ground.

The caterpillars hide under the soil or litter by day. When mature, they pupate in the soil.

The common name 'cutworm' refers to the habit of large larvae feeding on young plants and stems at or below the soil surface and often cutting off entire plants.

Cutworm caterpillars grow to about 40 mm in length but cannot typically be seen, as they hide under the soil or litter. Often they can be located by scratching the surface near damaged plants, where they are typically curled up in a defensive position.



DPIRD 'Cutworms': <u>https://www.agric.</u> wa.gov.au/pest-insects/cutwormpests-crops-and-pastures

DPIRD 'Diagnosing cutworm in canola and pulses': <u>https://www.</u> agric.wa.gov.au/mycrop/diagnosingcutworm-canola-and-pulses

cesar 'Cutworms': <u>http://www.</u> cesaraustralia.com/sustainableagriculture/pestfacts-south-eastern/ past-issues/2014/pestfacts-issue-no-4-5th-june-2014/cutworms/

PIRSA 'Cutworm alert': <u>http://www.</u> pir.sa.gov.au/research/services/ reports\_and\_newsletters/pestfacts\_ newsletter/pestfacts\_issue\_3\_2016/ cutworm\_alert\_for\_the\_sa\_mallee



<sup>10</sup> DPIRD website (2016) Managing insects, weeds and disease in albus lupin variety Andromeda, <u>https://www.agric.wa.gov.au/lupins/</u> managing-insects-weeds-and-disease-albus-lupin-variety-andromeda



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These pests are most damaging in autumn when large caterpillars transfer from summer and autumn weeds on to newly emerged crop seedlings.

Whole paddocks of cereal, lupin or canola seedlings may be destroyed or severely thinned early in the season. Therefore, early detection is important.

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If required, cutworms can be easily controlled with standard registered insecticides and spot spraying affected areas can often provide adequate control.

Early and complete control of the green bridge two weeks before planting will minimise survival of cutworm larvae.

Approved insecticides for use on cutworm in lupins in the southern region include:

- » Zeta-cypermethrin (75 mL/ha Fury® 100EC)
- » Deltamethrin (200 mL/ha)
- » Beta-Cypermethrin (90 mL/ha)
- » Alpha-Cypermethrin (75 mL/ha).

#### 6.4.10 Weed web moth (Achrya affinitalis)



**Figure 12:** Weed web moth larvae. This is a sporadic pest of lupin in the southern region.

(SOURCE: Andrew Weeks, **cesar**)

Weed web moth larvae are slender and grow to 15 mm in length, are grey-green and pale brown in colour and have a distinctive black head.

These pests generally have a dark line down the middle of their back, with three rows of dark spots on either side above distinctive cream bands.

When disturbed, larvae wriggle violently or crawl around rapidly.

Moths are about 12 mm in length, with buff coloured wings that have darker brown or reddish flecks, mainly on the forewings.

When monitoring, check all young broadleaf crops for leaf feeding and webbing.

This sporadic pest is often abundant in seasons with early autumn rainfall and warm weather.

#### ) MORE INFORMATION

PIRSA 'Weed Web Moth': http://www.pir.sa.gov.au/research/ services/reports\_and\_newsletters/ pestfacts\_newsletter/pestfacts\_ issue\_1\_2016/weed\_web\_moth

cesar 'Weed Web Moth': <u>http://www.cesaraustralia.com/</u> <u>sustainable-agriculture/pestfacts-</u> <u>south-eastern/past-issues/2010/</u> pestfacts-issue-no-1-28th-april-2010/ <u>weed-web-moth/</u>





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The weed web moth skeletonises foliage and web leaves together. Seedlings can be defoliated and die. Infested paddocks look wilted.

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Monitor crops after emergence, as seedlings are at most risk of damage. Look for early infestation signs such as terminal damage, webbing and windowing of leaves. Moths can migrate from long distances and larvae can suddenly appear in very large numbers.

Insecticide use can be warranted if large numbers build up. This typically occurs where there has been an abundance of green plant material during spring and summer.

Management difficulties have occurred in the past in the southern region because this pest requires higher rates of insecticides than commonly used against cutworm and pasture webworm.

There are registered insecticides available for use in lupin crops and it is advised to closely check labels in each state.

#### 6.4.11 Grey-banded leaf weevil (Ethemaia sellata)



**Figure 13:** The Grey banded leaf weevil is widespread across the southern cropping region and tends to be found close to fence lines.

Adult grey-banded leaf weevils are known to attack several winter crops, including canola and lupin, and may also be a grain contaminant at harvest.

It is understood these pests may feed preferentially on malvaceous weeds (such as marshmallow, *Althaea officinalis*) and some ornamental plants that could be the source of infestations in crops.

This weevil species is widespread across the southern cropping region.

It is recommended that crops are monitored closely, particularly near fence lines, as adults tend to move into crops from host weeds and scrub.

Damage includes leaf scalloping, chewing of leaf edges and thinning of plants.

An insecticide border spray at crop emergence can help to control grey-banded leaf weevil before it moves into the crop.

### i) MORE INFORMATION

DPIRD 'Diagnosing Weevils in Lupins and Field Peas': <u>https://www.agric.</u> <u>wa.gov.au/mycrop/diagnosing-</u> <u>weevils-lupins-and-field-peas</u>

cesar 'Grey-banded Leaf Weevil': <u>http://cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern/past-issues/2009/pestfacts-issue-no-6-16th-july-2009/grey-banded-leaf-weevil/</u>

Pest Facts 'Issue 5, 2015': http://www.pir.sa.gov.au/ research/services/reports\_and\_ newsletters/pestfacts\_newsletter/ pestfacts\_Issue\_5\_2015/pestfacts\_ issue\_5,\_2015\_-\_single\_page\_view





**MORE INFORMATION** 

HerbiGuide 'European Earwig': http://www.herbiguide.com.au/ Descriptions/hg\_European\_Earwig.

DPIRD 'Management of the European Earwig': <u>https://www.agric.wa.gov.au/</u> pome-fruit/management-european-

DPIRD 'Diagnosing the European

Earwig': https://www.agric.wa.gov.au/

mycrop/diagnosing-european-earwig

earwig?page=0%2C1

cesar 'European Earwig':

insect/European-earwig

http://www.cesaraustralia.com/ sustainable-agriculture/pestnotes/

htm

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Paddock boundaries should be checked every few days until the crop has four to five true leaves.

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There are no insecticides registered to control grey-banded leaf weevils in lupin crops. Weevil numbers in crop can be reduced by controlling plant hosts, such as capeweed (*Arctotheca calendula*) and marshmallow, before sowing.

#### 6.4.12 European earwig (Forficula auricularia)



**Figure 14:** Parts of the southern cropping region have European earwig problems in *lupin crops*.

(SOURCE: Nick Monaghan, lifeunseen.com)

Minimum and no-tillage farming operations have led to an increase in European earwig populations in some southern areas.

Adult earwigs range from 12 to 20 mm in size, with brown bodies and pincers.

These insects will usually complete one generation per year and can survive in a range of environments.

Adults are inactive during summer and juveniles become active in winter and then mature during spring.

European earwigs are nocturnal and crop monitoring should take place at night.

This pest mainly attacks canola but will also target cereals and lupin.

Damage will be scattered and clear chewing of the stems and leaves of emerging seedlings will be evident.

Earwigs can kill the crop plants, slow development and chew through seed pods.

In most years, control is not economical and there are no in-crop insecticide options for use in lupin.

Spread of these insect pests can be minimised by ensuring all machinery, vehicles and equipment are clean. Reducing stubble retention and burning stubbles are also successful methods to reduce populations, but it is advised to be mindful of the risks of wind and water erosion.





### i) MORE INFORMATION

GRDC 'Grain and Legume Handbook': <u>https://grdc.com.au/</u> grainlegumehandbook

GRDC 'Fact Sheet – Plant Parasitic Nematodes': <u>www.grdc.com.au/</u> <u>GRDC-FS-Plant-Parasitic-Nematodes-</u> <u>SW</u>

Australian Pesticides and Veterinary Medicines Association: http://apvma.gov.au/

CropPro: <u>http://www.croppro.com.au/</u> crop\_disease\_manual/ch10.php

SARDI PREDICTA® B: <u>http://pir.sa.gov.</u> au/research/services/molecular\_ diagnostics/predicta\_b

DPIRD-GRDC MyCrop and MyCropApp: <u>https://grdc.com.au/apps</u>

DPIRD Diagnostic Laboratory Services (DDLS)-Plant Pathology: <u>https://www.</u> <u>agric.wa.gov.au/ddls-seed-testing-</u> <u>and-certification</u>

# Root diseases and nematodes

#### 7.1 Overview

Incidence of root and hypocotyl diseases in lupin crops has declined in the past 20 years, but remains an issue for some southern region growers to manage.

Root rot occurs in most narrow leafed lupin paddocks but, in most areas, it typically has only a small impact on crop development and major yield losses are uncommon.

In paddocks where high levels of root rot occur, plant establishment and seedling vigour can be affected.

*Pleiochaeta setosa* and *Rhizoctonia solani* are the major pathogens causing root or hypocotyl infection of lupin plants.

Hypocotyl rot risk is higher with legume-pasture rotations and can typically be found on most soil types.

When a root disease is present in a crop, little can be done to manage it in that cropping season.

It is, therefore, vital to correctly identify the cause for appropriate management before sowing the next lupin crop.

Correct identification can be made by assessing in-crop symptoms and the root and hypocotyl of affected plants.

Poor emergence, patches in crops, uneven and stunted growth, yellowing of plants and wilting or death under water stress – particularly at flowering and grain fill – can indicate the presence of root disorders.

But these above-ground symptoms are difficult to diagnose, as many biotic and abiotic disorders can have similar above ground expression.

Soil testing and monitoring, through the South Australian Research and Development Institute's (SARDI) PREDICTA® B sampling service or Department of Primary Industries and Regional Development (DPIRD) – formerly Department of Agriculture and Food Western Australia (DAFWA) – Diagnostic Laboratory Services (DDLS)-Plant Pathology, can help correctly diagnose, monitor and manage root and hypocotyl diseases and nematodes in lupin crops. For more information go to <u>http://pir.sa.gov.au/research/ services/molecular\_diagnostics/predicta\_b</u> and <u>https://www.agric.wa.gov.au/ddlsseed-testing-and-certification</u>.

Lupin can be an excellent management tool for reducing some nematode species, but is highly susceptible to damage from others.

This reiterates the importance of correct species identification for rotation planning to manage root disease and nematode issues.





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Agriculture Victoria 'Brown Leaf Spot and Root Rot of Lupins': http://agriculture.vic.gov.au/ agriculture/pests-diseases-andweeds/plant-diseases/grains-pulsesand-cereals/brown-leaf-spot-androot-rot-of-lupins

DPIRD-GRDC MyCrop: <u>https://www.</u> agric.wa.gov.au/mycrop/diagnosingleiochaeta-root-rot-narrow-leafedlupins

DPIRD 'Lupin Root Diseases': https://www.agric.wa.gov.au/lupins/ lupin-root-diseases-diagnosis-andmanagement



#### 7.2 Pleiochaeta root rot (Pleiochaeta setosa)



#### Figure 1: Pleiochaeta root rot infection on lupin stems.

(SOURCE: GRDC Grain Legume Handbook)

- Rarely leads to major crop losses (except in some situations where lupin is sown after lupin on very infertile sands)
- Minimum tillage and deep ripping can reduce disease incidence
- Rotations with non-host crops can reduce spore concentrations in soil.

Pleiochaeta root rot is caused by the fungus *Pleiochaeta setosa* that also causes Brown leaf spot of lupin.

Spores are produced on fallen Brown spot-infected leaves and become incorporated into the top few centimetres of soil, where these can persist during summer and across several years.

The spores germinate in the next lupin crop and infect the plant roots of seedlings, causing pleiochaeta root rot.

Spores that have survived on the soil surface can also be splashed upwards by rain droplets and infect leaves and stems, causing brown leaf spot. This continues the disease cycle.

Pleiochaeta root rot creates lesions on roots, but rarely leads to major crop losses where reduced tillage and extended lupin rotations are used.

Incidence can be higher in paddocks with close lupin rotations and where seeding operations place spores in the root zone.

Disease severity and yield impact is determined by the number and distribution of spores in the soil. A high number of spores distributed close to the seed can cause severe disease.

In-crop symptoms of pleiochaeta root rot include wilted, weak or dying seedlings that can be scattered in the paddock or on particular soil types.

Infection produces dark brown lesions on the tap and lateral roots, leading to stripping of the outer layer of the root. In severe cases there is complete rotting of the root.

Taproots are susceptible for about six to eight weeks after germination. But new lateral roots are susceptible during emergence of the crop and are often pruned-off.











**Figure 3:** Infection cycle of Pleiochaeta root rot. (SOURCE: DPIRD)





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- Management of pleiochaeta root rot
  - » Use reduced or minimum tillage
  - » Variety tolerance and choice is important
  - » Deep tillage spading or mouldboard ploughing can suppress disease severity
  - » Rotate lupin with non-host crops (such as cereals, canola, pasture).

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- » Control brown leaf spot in preceding lupin crops
  - No fungicide treatments are registered for in-crop use.<sup>1</sup>

Minimum or reduced tillage sowing systems have been shown to reduce the incorporation of pleiochaeta root rot spores into the rooting zone of the soil profile.

Rotating lupin with non-host crops, such as cereals, canola or pasture, can lower the concentration of soil-borne spores.

Controlling Brown leaf spot in preceding lupin crops can also reduce the amount of spores returned to  $\mathrm{soil.}^2$ 

Fungicide seed treatments containing the Group 2 actives iprodione or procymidone (used to control Brown leaf spot in the southern region) do not tend to provide consistent control of pleiochaeta root rot.

There are no registered fungicide treatments to use in-crop.

#### 7.3 Rhizoctonia bare patch (Rhizoctonia solani AG8)

- Occurs on most soil types
- Affects lupin and most other crops and pastures
- Rotations tend not to break the disease cycle
- All commercial lupin varieties equally susceptible
- Affected paddocks have distinct patches of stunted or dying crops three to six
   weeks after sowing
- Yields are severely depleted in patch areas
- Some tillage systems can reduce disease incidence
- Seed or in-furrow fungicides are not registered for use in lupin crops.

Rhizoctonia bare patch is caused by the fungus *Rhizoctonia solani* (AG8) and has a wide plant host range, making rotation with cereals, canola or other pulses mostly ineffective in suppressing disease incidence in lupin crops.

But research and grower experience in South Australia and Western Australia have found grass-free canola and pulse crops and pastures can help to reduce inoculum levels in soil to benefit subsequent crops.

Rhizoctonia bare patch is found in most soil types, especially in sandplain areas, and affects all commercially available lupin varieties.

The fungus colonises either living plant tissue or dead organic material, allowing it to survive across years.

After autumn rain, it grows rapidly to infect young seedlings and distinct patches of stunted or dying plants are visible in the crop three to six weeks after sowing.

Long-term trials show rhizoctonia bare patch can also attack crops throughout the growing  $\ensuremath{\mathsf{season.}}^3$ 

- 2 DPIRD-GRDC (2016) MyCrop diagnostic tool Diagnosing pleiochaeta root rot in narrow-leafed lupins, <u>www.aqric.wa.gov.au/mycrop/diagnosing-pleiochaeta-root-rot-narrow-leafed-lupins</u>
- 3 McKay, A (2006) Fungicide Control of Rhizoctonia Part B Syngenta, SARDI, University of SA, CSIRO Adelaide, DAFWA, <u>http://projects.grdc.com.au/projects.php?action=view\_project&project\_id=653</u>

#### ${f (i)}$ more information

DPIRD-GRDC MyCrop: <u>https://www.</u> agric.wa.gov.au/mycrop/diagnosingrhizoctonia-bare-patch-grainlegumes-0

SARDI 'PREDICTA® B': <u>http://pir.sa.gov.</u> au/research/services/molecular\_ <u>diagnostics/predicta\_b</u>



<sup>1</sup> DPIRD-GRDC (2016) MyCrop diagnostic tool – Diagnosing pleiochaeta root rot in narrow-leafed lupins, <u>www.agric.wa.gov.au/mycrop/</u> diagnosing-pleiochaeta-root-rot-narrow-leafed-lupins



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Yield losses from this root disease in lupin crops are typically proportional to the area of paddocks affected by patches, which can range from 0.5 to five metres in diameter and produce virtually no grain.<sup>4</sup>

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The tap and lateral roots of affected plants are 'pinched off' by dark brown lesions, often having a spear-tipped appearance. As the season progresses, damaged plants often die.

#### Management of rhizoctonia bare patch

- » Use deep cultivation at sowing with a narrow tyne 10-15 cm below seed
- » Deep ripping to 25-30 cm immediately prior to sowing can suppress disease
- » Ensure good crop nutrition
- » Avoid herbicide damage to roots
- » No fungicide seed dressing or foliar products are registered for use in lupin
- » Rotation and variety selection will not provide total control.<sup>5</sup>

Deep cultivation at sowing with a narrow tyne 10-15 cm below the seed, or deep ripping to 25-30 cm prior to sowing, have been shown to be the most effective methods for reducing lupin crop damage caused by rhizoctonia root rot.<sup>6</sup>

Cultivation with knife-point soil openers can disturb fungal growth in the soil and encourage better root growth, compared to disc sowing systems.

It is recommended to sow at the optimal time, to ensure good crop growth with adequate plant nutrition and avoid herbicide damage to roots to reduce disease impact.

Research has shown control of the 'green bridge' of weeds and crop volunteers between crops and ensuring good weed control in-crop can also help to reduce crop losses.<sup>7</sup>

Crop rotation and variety selection will not totally control rhizoctonia root rot and there are no registered fungicide seed dressings or foliar actives for use in lupin crops.



<sup>4</sup> DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia bare patch in grain legumes, <u>https://www.agric.wa.gov.au/</u> mycrop/diagnosing-rhizoctonia-bare-patch-grain-legumes-0

<sup>5</sup> DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia bare patch in grain legumes, <u>https://www.aqric.wa.gov.au/</u> mycrop/diagnosing-rhizoctonia-bare-patch-grain-legumes-0

<sup>6</sup> DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia bare patch in grain legumes, <u>https://www.agric.wa.gov.au/</u> mycrop/diagnosing-rhizoctonia-bare-patch-grain-legumes-0

<sup>7</sup> GRDC (2016) Tips and Tactics – Rhizoctonia – Western Region, <u>www.grdc.com.au/TT-Rhizoctonia</u>



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# MORE INFORMATION

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CropPro 'Phytophthora Root Rot of Lupins': <u>http://www.croppro.com.au/</u> <u>crop\_disease\_manual/ch09s04.php</u>

GRDC 'The watch outs for pulse diseases in 2017': <u>https://grdc.com.</u> <u>au/resources-and-publications/grdc-</u> <u>update-papers/tab-content/grdc-</u> <u>update-papers/2017/02/the-watch-</u> <u>outs-for-pulse-diseases-in-2017</u>

NSWDPI 'Phytophthora root rot of lupins': <u>http://archive.dpi.nsw.gov.</u> <u>au/\_\_data/assets/pdf\_file/0019/157411/</u> <u>pulse-point-17.pdf</u>





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**Figure 4:** Phytophthora root rot can cause significant lupin losses in susceptible areas in some seasons, with damage in control plots of chickpea with no chemical protection shown here at a NSW trial site in 2017.

- Warm soil and waterlogging are conducive to disease
- Leaves turn yellow and die, typically within 24 hours
- Plants wilt and die during pod filling
- Symptoms include a rotted woody taproot with few lateral roots
- There is no known resistance in lupin.

Phytophthora root rot (caused by the organism *Phytophthora spp* in narrow leafed lupin and *P. cryptogea* in albus lupin) has been a significant disease of lupin crops in north eastern VIC and southern NSW. It was widespread in these regions in 2016 on the back of above average rainfall in late winter and early spring and has also been found to cause premature wilting in lupin crops on the SA Lower Eyre Peninsula in some seasons.<sup>8</sup>

This disease tends to strike pulse crops in areas prone to waterlogging, from periods of as short as eight hours, in low lying paddocks and in soils prone to hardpans (which can develop perched water tables).<sup>9</sup>

The phytophthora root rot pathogen infects lupin roots and is typically expressed in spring, when plants prematurely die often around pod filling. As the soil starts to dry out, the infected and damaged root system can no longer support the plant and this leads to premature death.<sup>10</sup>



<sup>8</sup> Lindbeck, K (NSW Department of Primary Industries, Wagga Wagga Agricultural Institute, Wagga Wagga, NSW), Moore, K (NSWDPI Agricultural Institute, Calala, NSW), Richards, M & O'Connor, G (NSWDPI Agricultural Institute, Wagga Wagga, NSW) (2017), The watch outs for pulse diseases in 2017, <u>https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-updatepapers/2017/02/the-watch-outs-for-pulse-diseases-in-2017</u>

<sup>9</sup> Lindbeck, K (NSW Department of Primary Industries, Wagga Wagga Agricultural Institute, Wagga Wagga, NSW), Moore, K (NSWDPI Agricultural Institute, Calala, NSW), Richards, M & O'Connor, G (NSWDPI Agricultural Institute, Wagga Wagga, NSW) (2017), The watch outs for pulse diseases in 2017, <a href="https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/tab-

<sup>10</sup> Lindbeck, K (NSW Department of Primary Industries, Wagga Wagga Agricultural Institute, Wagga Wagga, NSW), Moore, K (NSWDPI Agricultural Institute, Calala, NSW), Richards, M & O'Connor, G (NSWDPI Agricultural Institute, Wagga Wagga, NSW) (2017), The watch outs for pulse diseases in 2017, <u>https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/the-watch-outs-for-pulse-diseases-in-2017</u>



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In-crop symptoms include leaves that suddenly turn yellow and drop, often within a 24 hour period. A dark, sunken lesion may extend from the base and often up one side of the stem. Infected plants are found to have a rotted taproot when pulled out of the ground. The taproot is woody in appearance with little if any outer tissue remaining and few, if any, lateral roots.<sup>11</sup>

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The pattern of distribution in a crop can vary from single scattered plants to large areas of a paddock, often in low lying areas. Plants tend to fail to fill pods or produce small seed.<sup>12</sup>

The fungus causing phytophthora root rot survives in the soil and becomes established when a new crop is sown. To date it is not known what other hosts carry this fungal pathogen between lupin crops.<sup>13</sup>

There appear to be several essential prerequisites for this disease to develop, including soil temperatures of above 15°C. This explains why symptoms in the paddock often do not appear until early spring as soil temperatures rise.<sup>14</sup>

A period of waterlogging also appears to be required for root infection to occur. Trials have found narrow leafed lupin can survive flooding for at least eight days in the absence of phytophthora root rot, but die within a short period when the pathogen is present.<sup>15</sup>

#### Management of phytophthora root rot

- In susceptible areas avoid sowing lupin in paddocks prone to waterlogging
- Avoid sowing into soils with a hardpan problem.

Disease management for phytophthora root rot is difficult because of the extended period of survival of the fungus in the soil. Methods to minimise the occurrence of the disease include crop rotation and avoiding paddocks with a known waterlogging or hardpan problem.<sup>16</sup>

Hardpans can be identified by pushing a spade or shovel into the soil. A layer of resistance is felt where a hardpan is present. Alternatively, dig up some plants and observe the root growth. The regular occurrence of distorted taproots shaped like an 'L' indicate a hardpan. Consult your local agronomist or adviser to develop a strategy to manage them.<sup>17</sup>

As the species and host range of phytophthora root rot is indefinite at this stage, it is not possible to recommend suitable crop rotations to minimise disease impact.<sup>18</sup>

- 12 CropPro (2017), Phytophthora Root Rot of Lupins, <u>http://www.croppro.com.au/crop\_disease\_manual/ch09s04.php</u>
- 13 CropPro (2017), Phytophthora Root Rot of Lupins, <u>http://www.croppro.com.au/crop\_disease\_manual/ch09s04.php</u>
- 14 CropPro (2017), Phytophthora Root Rot of Lupins, <u>http://www.croppro.com.au/crop\_disease\_manual/ch09s04.php</u>
- 15 CropPro (2017), Phytophthora Root Rot of Lupins, <u>http://www.croppro.com.au/crop\_disease\_manual/ch09s04.php</u>
- 16 Lindbeck, K (NSW Department of Primary Industries, Wagga Wagga Agricultural Institute, Wagga Wagga, NSW), Moore, K (NSWDPI Agricultural Institute, Calala, NSW), Richards, M & O'Connor, G (NSWDPI Agricultural Institute, Wagga Wagga, NSW) (2017). The watch outs for pulse diseases in 2017, <u>https://grdc.com.au/resources-and-publications/grdc-update-papers/2017/02/the-watch-outs-for-pulse-diseases-in-2017</u>
- 17 Carpenter, D. NSWDPI, Pulse Point Phytophthora root rot of lupins, <u>http://archive.dpi.nsw.gov.au/\_\_data/assets/pdf\_file/0019/157411/</u> pulse-point-17.pdf
- 18 Carpenter, D. NSWDPI, Pulse Point Phytophthora root rot of lupins, <u>http://archive.dpi.nsw.gov.au/\_\_\_\_data/assets/pdf\_\_file/0019/157411/</u> pulse-point-17.pdf



<sup>11</sup> CropPro (2017), Phytophthora Root Rot of Lupins, http://www.croppro.com.au/crop\_disease\_manual/ch09s04.php



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DPIRD-GRDC MyCrop: <u>https://www.</u> agric.wa.gov.au/mycrop/diagnosingrhizoctonia-hypocotyl-rot-narrowleafed-lupins

DPIRD 'Lupin Root Disease': <u>https://</u> www.agric.wa.gov.au/lupins/ lupin-root-diseases-diagnosis-andmanagement 7.5 Rhizoctonia hypocotyl rot, or rhizoctonia root rot (*Rhizoctonia solani*)

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**Figure 5:** *Rhizoctonia can cause reddish-brown sunken lesions on the below ground portion of the stem of crops – as illustrated in this wheat plant.* (SOURCE: GRDC)

- Affects all lupin varieties and most other crop and pasture legumes
- Incidence is relatively low
- Affected crops can have poor plant establishment
- Rotation with non-legumes can break disease cycles
- Cultivation practices are ineffective.

Rhizoctonia hypocotyl rot, or root rot, is caused by the soil-borne ZG3, ZG4 and ZG6 strains of the fungus *Rhizoctonia solani*.

These pathogens are related to the strains causing rhizoctonia bare patch and affect all lupin varieties and most other crops and pasture legumes.

Incidence of hypocotyl rot in the southern region is typically relatively low, but can occur in most soil types and reduces plant establishment in affected crops.

The bulk of fungal inoculum is found in the top 5 cm of soil, where it can survive for at least two years in remnant organic matter.

With the onset of opening rains, the fungus grows and infects susceptible seedlings. It is more active in warm soil and tends to be more prevalent in early sown crops.





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Risks of infection are highest in lupin crops following a legume pasture phase as a result of disease build-up and the capacity of fast-germinating pasture seedlings to host infection prior to lupins germinating.

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When a root disease such as hypocotyl rot is present, very little can be done to manage it during that cropping season.

It is, therefore, advised to correctly identify the cause with soil sampling to allow appropriate management before sowing the next lupin crop.

Above ground symptoms of rhizoctonia hypocotyl rot in lupin crops include clumps of poor emergence, uneven and stunted plant growth, wilting or death.

It is the most easily diagnosed of all lupin root diseases, causing reddish-brown sunken lesions on the hypocotyl (below ground portion of the stem).

From emergence until about eight-leaf stage, infected seedlings wilt and die as lesions grow and rot through the hypocotyl.

Infected plants that survive past the eight to 10-leaf stage often remain stunted and are less productive than healthy plants.<sup>19</sup>

#### Management of rhizoctonia hypocotyl rot

- » Avoid lupin rotations after legume pasture
- » Shallower sowing can reduce hypocotyl exposure to the fungus
- Avoid sowing very early into warm soil in high risk paddocks
- » Higher sowing rates may compensate for establishment losses.

Crop rotation can be useful to break the rhizoctonia hypocotyl root rot cycle and, in high-risk areas, it may be beneficial to not sow consecutive lupin sequences or lupin after a legume pasture.

Shallower sowing can reduce exposure of the hypocotyl to the fungal inoculum and it is advised that sowing very early into warm soil in paddocks with known disease risk should be avoided.

Increasing sowing rate by 10-25 percent can help to compensate for establishment losses in high risk paddocks.  $^{\rm 20}$ 

19 DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia hypocotyl rot in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-hypocotyl-rot-narrow-leafed-lupins</u>



<sup>20</sup> DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing rhizoctonia hypocotyl rot in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-hypocotyl-rot-narrow-leafed-lupins</u>



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DPIRD-GRDC MyCrop: <u>https://www.</u> agric.wa.gov.au/lupin-diagnostic-tool

GRDC 'Grain Legume Handbook': <u>https://grdc.com.au/</u> grainlegumehandbook



### 7.6 Minor root diseases in southern region lupin crops

Table 1: Summary of minor root diseases of lupin in the southern region.<sup>21</sup>

Disease			
Charcoal rot ( <i>Macrophomina phaseolina</i> )			
Risks	Moisture-stressed crops; survives in soil for multiple years.		
Symptoms	Premature senescence of individual plants or patches in-crop. Stems and taproots have ash-grey discoloration (when split open) due to masses of tiny black microsclerotia embedded in the tissue.		
Management	Does not typically reduce crop yields.		
Useful resources	DPIRD-GRDC MyCrop: <u>https://www.agric.wa.gov.au/lupins/</u> lupin-root-diseases-diagnosis-and-management		
Pythium root rot			
Risks	Most soil types, especially shallow duplex soils and other soils prone to sub-soil saturation.		
Symptoms	Roots develop a black rot; hypocotyls develop water- soaked lesions. Infection can kill emerging seedlings or create weak and stunted plants that wilt at the start of stem elongation.		
Management	Avoid sowing lupin in waterlogging-prone soils; crop rotations.		
Useful resources	GRDC Fact Sheet 'Root disease', <u>https://grdc.com.au/uploads/documents/GRDC_FS_Pythium.pdf</u> and DAFWA Lupin disease hub, <u>https://www.agric.wa.gov.au/lupins/ lupin-root-diseases-diagnosis-and-management</u>		
Abiotic root damage			
Risks	Various soil structures and properties.		
Symptoms	Impermeable hardpans and duplex soils can cause damaged or bent taproots and poorly developed root systems. Waterlogging can result in soft discolored roots, poorly developed root systems and yellowing of plants. Chemical damage from triazine or sulfonylurea herbicides or poor fertiliser placement can cause rotting, pruning or reduced development of roots.		
Management			
Useful resources	DPIRD-GRDC MyCrop: <u>https://www.agric.wa.gov.au/lupins/</u> lupin-root-diseases-diagnosis-and-management		



<sup>21</sup> DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Lupins, <u>https://www.agric.wa.gov.au/lupin-diagnostic-tool</u>



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GRDC 'Tips and Tactics – Root Lesion Nematodes': <u>https://grdc.com.au/</u> <u>Resources/Factsheets/2015/03/Root-</u> <u>Lesion-Nematodes</u>

GRDC 'Fact Sheet – Plant Parasitic Nematodes' (Southern Region): <u>https://grdc.com.au/Resources/</u> <u>Bookshop/2010/10/Plant-Parasitic-</u> <u>Nematodes-Fact-Sheet-Southern-Western-Region</u>

GRDC 'Paddock Practices – Managing Root Lesion Nematodes Pre-sowing': <u>https://grdc.com.</u> <u>au/Media-Centre/Media-News/</u> West/2016/03/Managing-root-lesionnematodes-presowing

#### 7.7 Nematodes



**Figure 6:** Root lesion nematodes are worm-like microscopic endoparasites that feed on plant roots and can cause patches in crops.

(SOURCE: DPIRD)

- Lupin crops can help reduce the Root lesion nematodes (RLN) *P. neglectus* and *P. thornei*
- The RLN P. penetrans and P. crenatus have a very low presence
- Lupin is very susceptible to P. penetrans
- There are no in-crop options to control nematodes
- Crop rotation can help reduce crop damage
- Rotation is influenced by species of nematode present in soil
- Soil and/or plant root testing will identify species and levels of nematodes.

Root lesion nematodes (RLN) are the main nematode species that affect all southern region crops, including lupin, and incidence is increasing where intensive cropping occurs.

These worm-like microscopic endoparasites feed on plant roots.

The main RLN species found in the southern region are *Pratylenchus neglectus* and *P. thornei*.

Lupin crops are an excellent management tool for helping to reduce *P. neglectus* and *P. thornei* burdens in paddocks, but are very susceptible to damage from *P. penetrans*. Testing by SARDI in 2016 found minimal risk of incidence of *P. Penetrans* in SA and low levels of risk of incidence from 2016 samples taken from northern VIC and southern NSW.<sup>22</sup>

This reiterates the importance of correctly diagnosing the RLN species in paddocks with soil testing using accredited laboratories.

Correct RLN identification will also help the grains industry characterise nematode distribution and gather further resistance information for crop types and varieties grown in the southern region.

Such research is vital because no chemicals are available to economically control nematodes in broadacre cropping systems. Incidence of RLN in the southern region and maps identifying medium and high risk areas 2016 PREDICTA® B tests tests can be found on the SARDI website at: <a href="http://pir.sa.gov.au/\_\_\_data/assets/image/0003/293142/Australia\_P\_penetrans\_map\_2016.jpg">http://pir.sa.gov.au/\_\_\_data/assets/image/0003/293142/Australia\_P\_penetrans\_map\_2016.jpg</a>



<sup>22</sup> SARDI (2017), Disease Risk Map, P. Penetrans, <u>http://pir.sa.gov.au/\_\_\_data/assets/image/0003/293142/Australia\_P\_penetrans\_\_\_\_\_map\_2016.jpg</u>



**MORE INFORMATION** 

SARDI 'PREDICTA® B': http://pir.sa.gov.

**DPIRD Diagnostic Laboratory Services** 

(DDLS)-Plant Pathology: https://www.

agric.wa.gov.au/ddls-seed-testing-

au/research/services/molecular\_

diagnostics/predicta\_b

and-certification

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In-crop symptoms of nematodes are often indistinct, difficult to identify and commonly mistaken for nutrient deficiencies, soil limiting factors or presence of rhizoctonia.

Big patches, or uneven waves of crop growth, may be evident in paddocks. Up close, plants are often smaller, look chlorotic (yellowing), have reduced tillering, wilt easily and may be dying-off.

If nematodes are present, roots may be stunted, lack lateral roots and may have brown lesions from nematode pruning.

#### Testing to identify nematodes

A pre-sowing soil test using PREDICTA® B, offered by accredited advisers through SARDI, can diagnose *P. neglectus* and *P. thornei*, along with Cereal cyst nematode (*Heterodera avenae*). Soil testing and in-crop plant root testing for nematode diagnosis can also be carried out by DPIRD's Diagnostic Laboratory Services (DDLS)-Plant Pathology.

Soil sampling guidelines include:

- » Dig soil to a depth of 0-10 cm
- » Take samples in the crop row, close to roots
- » Sample at six to 12 locations towards the margins of poor growth areas
- » Place all samples in a bucket and mix gently
- $\, \ast \,$  Remove a 500 g sample from the bucket and put in plastic bag
- » Collect a second sample from a healthy crop area
- » Include paddock history and notes on each sample to send to the laboratory.

Plant sampling guidelines include:

- » Collect plants from several locations towards the margins of poor crop growth
- » Use a trowel/shovel to keep root systems intact
- » Retain the soil ball to protect roots in transit to the laboratory.<sup>23</sup>

#### Management of nematodes

- » No in-crop options can stop nematode damage
- » Diagnose and monitor species and concentration levels using soil and root testing
- » Avoid growing lupin where *P. penetrans* is present
- » Maintain healthy soils and adequate crop nutrition.

Planning crop rotations with resistant varieties, or non-host break crops and pastures, can help inhibit nematode reproduction/build-up (resistance) and potentially boost crop yields to non-limiting levels under RLN pressure (tolerance).

If there are high or very high RLN levels in a paddock (more than 10 nematodes/mL of soil or more than 10,000 nematodes/gram dry root – severity score three and four) – it is recommended to grow a moderately resistant (MR) or resistant (R) crop for one to two cropping seasons.<sup>24</sup>

Lupin shows good resistance for *P. neglectus* and *P. quasitereoides* and can be grown where these are present to help break nematode cycles.

But lupin is susceptible to *P. penetrans* and it is advisable to avoid planting them where this nematode is present.

Maintaining healthy soils and good crop nutrition, especially at crop establishment, can also help to reduce the long-term impact of nematodes on lupin production.



<sup>23</sup> Collins, S (2014), Know your nematodes and set up a crop defence system in 2015, GRDC, <u>https://grdc.com.au/Media-Centre/Media-News/West/2014/07/Know-your-nematodes-and-set-up-a-crop-defence-system-in-2014</u>

<sup>24</sup> Collins, S (2014), Know your nematodes and set up a crop defence system in 2015, GRDC, <u>https://grdc.com.au/Media-Centre/Media-News/West/2014/07/Know-your-nematodes-and-set-up-a-crop-defence-system-in-2014</u>



### i) MORE INFORMATION

Agriculture Victoria 'Pulse Disease Guide': <u>http://agriculture.vic.gov.au/</u> agriculture/pests-diseases-and-weeds/ plant-diseases/grains-pulses-and-cereals/ pulse-disease-guide#utm\_source=wwwvic-gov-au&utm\_medium=vanity-url-301ssredirect&utm\_content=pulse diseaseguide&utm\_campaign=agriculture

NSW Department of Primary Industries 'Lupin Growth and Development': <u>http://</u> www.dpi.nsw.gov.au/\_\_data/assets/ pdf\_file/0006/516183/Procrop-lupingrowth-and-development.pdf

GRDC 'Crop Disease Au' App: <u>https://grdc.</u> <u>com.au/apps</u>

Australian Pesticide and Veterinary Medicines Authority: <u>http://apvma.gov.au/</u>

GRDC 'Crop Disease Au' App: <u>https://grdc.</u> <u>com.au/apps</u>

GRDC 'Grains and Legume Handbook – Chapter 7 Disease Identification and Control': <u>https://grdc.com.au/</u> <u>grainlegumehandbook</u>

Infopest: http://www.infopest.com.au/

CropPro: <u>http://www.croppro.com.au/</u> crop\_disease\_manual/ch10.php

DPIRD-GRDC MyCrop and MyCropApp: https://grdc.com.au/apps https://www.agric.wa.gov.au/mycrop

DPIRD Diagnostic Laboratory Services (DDLS)-Plant Pathology: <u>https://www.</u> <u>agric.wa.gov.au/ddls-seed-testing-andcertification</u>

GRDC 'The Current and Potential Costs from Diseases of Pulse Crops in Australia': <u>https://grdc.com.au/resources-</u> <u>and-publications/all-publications/</u> <u>publications/2012/06/the-current-and-</u> <u>potential-costs-from-diseases-of-pulse-</u> <u>crops-in-australia</u>

DPIRD Lupin Diagnostic Tool: <u>www.agric.</u> wa.gov.au/lupin-diagnostic-tool

# **Foliar diseases**

#### 8.1 Overview

The main fungal and viral diseases affecting lupin foliage, stems and pods in the southern region are:

- » Anthracnose (Colletotrichum lupini)
- » Brown leaf spot (Pleiochaeta setosa)
- » Phomopsis stem and pod blight (*Phomopsis leptostromiformis* and *Diaporthe toxica*)
- » Cucumber mosaic virus (CMV)
- » Bean yellow mosaic virus (BYMV)
- » Sclerotinia stem and collar rot (*Sclerotinia sclerotiorum* and *Sclerotinia minor*).

Minor foliar diseases that can also affect lupin crops in the southern region in some years include:

- » Grey leaf spot (Stemphylium botryosum)
- » Cladosporium leaf spot (Cladosporium sp.)
- » Grey mould (Botrytis cinerea)
- » Bean leaf roll virus (BLRV)
- » Alfalfa mosaic virus (AMV)
- » Powdery mildew (Erysiphe polygoni).

Lupin yield losses from foliar diseases are typically rare in most southern growing areas due to widespread adoption of fungicide-based seed treatments and wider crop sequences.

But, left unchecked in some years and situations, several of the major diseases have potential to cause significant crop losses.

Damage can be prevented or curtailed with an integrated management approach involving variety choice, crop rotations, crop hygiene and targeted seed-based and foliar fungicide use.

Reducing the impact of these diseases will allow lupin production levels in South Australia, Victoria and New South Wales to be maintained. This, in turn, underpins cereal and canola production by supporting viable and profitable rotations — especially on sandy soils.

Lupin variety responses to a range of foliar diseases are shown in Table 1.1



CropPro (2016) Identification and management of field crop diseases in Victoria, GRDC and Department of Environment and Primary Industries Victoria, <a href="https://www.croppro.com.au/crop\_disease\_manual/">https://www.croppro.com.au/crop\_disease\_manual/</a>



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 Table 1: Lupin variety disease reactions.<sup>2</sup>

	Ю	Σ	۵		
	PLEIOCHAETA RC ROT	BROWN LEAF STE	BROWN SPOT PO	SISOMOHA	ANTHRACNOSE
NARROW LEAF					
PBA Bateman <sup>⊕</sup>			MS	MR	MR
Jenabillup <sup>⊕</sup>	R	R	MS	R	MS
Jindalee	MR	MR	R	R	MS
Mandelup <sup>⊕</sup>	R	MS	R	R	MR
PBA Barlock <sup>©</sup>		MS	MR	R	R
PBA Gunyidi <sup>©</sup>	R	MS	R	R	MR-R
Quilinock <sup>®</sup>	R	MR-MS	MR	S	S-VS
Wonga	R	MS	MR	S	R
ALBUS LUPIN					
Murringo <sup>®</sup>	MR			Intermed	VS
Kiev Mutant	VS	MR	MR	S	VS
Luxor <sup>®</sup>	R	MR	MR	S	VS
Rosetta	MR	MR	MR	S	VS

 $\label{eq:masses} \begin{array}{l} \mbox{Disease tolerance: R = Resistant } MR = Moderately resistant \\ MS = Moderately susceptible \\ S = Susceptible \\ VS = Very susceptible. \end{array}$ 

2 CropPro (2016) Identification and management of field crop diseases in Victoria, GRDC and Department of Environment and Primary Industries Victoria, <a href="http://www.croppro.com.au/crop\_disease\_manual/">http://www.croppro.com.au/crop\_disease\_manual/</a>



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A summary of lupin diseases, symptoms and control tactics is outlined in Table 2.

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 Table 2:
 Lupin disease guide summary.<sup>3</sup>

Disease	Organisms	Symptoms	Occurrence	Inoculum source	Control
Brown leaf spot	Pleiochaeta setosa	Dark spots on leaves and pods, leaves drop off, lesions may girdle stem	Very common but losses usually minor in dry areas, yield loss can be significant in cool damp areas	Spores in soil and lupin trash, rain splash and wind blown rain splash and wind blown rain splash	Fungicide seed dressings, crop rotation, variety selection, early sowing
Pleiochaeta root rot	Pleiochaeta setosa	Browning and rotting of tap and lateral roots, seedling plant death	Serious reduction in lupin plant density and vigour	Spores in soil infecting roots usually at seedling stage, spread also by rain splash	Rotation minimum 4 years between lupin, sowing 4—5 cm deep to avoid spore layer, fungicide seed dressings
Rhizoctonia	Rhizoctonia spp.	Bare patches in crop, spear tipped root ends, hypocotyl rot and stain	Can be severe in isolated patches, reduces stand density, favoured by minimum tillage, wet soils and mild conditions	Soil-borne infection on wide host range, survives as fungal fragments in soil and plant debris	Tillage prior and during sowing, rotation has no effect, increased seeding rate
Anthracnose	Colletotrichum lupini	Stems bend over, sticky dark brown lesions in crook of bend, pods and leaves above crook twist and deform, dark lesions with pale centres on leaves, stems and pods	Severe infections can result in complete crop failure	Spores surviving in soil are transported by vehicles, machinery, animals and people, spread in crop by rain splash and wind	Clean seed and machinery, 4 year break between lupin, resistant varieties, fungicide seed dressings reduce seedling infection
Cucumber mosaic virus	Virus	All growth after infection is dwarfed, leaflets are yellowed and bunched	Early widespread infection Severely reduces yield. Minor infections prevent use of harvested grain as seed	Seed-borne infection in narrow leaf lupin, aphids transmit the disease within a crop	Sow clean seed, use a seed test, high sowing rates and cereal barriers around crops reduce aphid transmission
Bean yellow mosaic virus	Virus	Brown streaks on stem, shepherd crook, pods blackened and flat, plants wilt and die	Occurs in all lupin growing areas. Can be severe in higher rainfall areas	Seed-borne in albus, aphid spread in crop, many host species	Sow virus free seed. High plant density, cereal barrier







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Agriculture Victoria 'Certification Requirements for Lupin Anthracnose': http://agriculture.vic.gov.au/ agriculture/horticulture/movingplants-and-plant-products/movingplants-within-victoria/complianceand-verification-agreements/ lupin-anthracnose

GRDC 'Grain Legume Handbook – Chapter 7 Disease Identification and Control': <u>https://grdc.com.au/</u> <u>grainlegumehandbook</u>

DPIRD Diagnostic Laboratory Services (DDLS)-Plant Pathology: <u>https://www.</u> agric.wa.gov.au/ddls-seed-testingand-certification

NSW Department of Primary Industry anthracnose eradication zone advice: <u>http://www.dpi.nsw.gov.au/</u> <u>biosecurity/plant/recent-pest-arrivals/</u> lupin-anthracnose

Agriculture Victoria quarantine rules: <u>http://agriculture.vic.gov.au/</u> <u>agriculture/horticulture/moving-</u> <u>plants-and-plant-products/moving-</u> <u>plants-within-victoria/compliance-</u> <u>and-verification-agreements/</u> <u>lupin-anthracnose</u>



#### 8.2 Anthracnose (Colletotrichum lupini)



**Figure 1:** Anthracnose can devastate lupin plants in susceptible varieties but can be managed.

(SOURCE: SARDI)

- Risk increases with rainfall, use of infected seed and disease susceptible varieties
- Albus and yellow lupin are more susceptible than narrow leafed lupin
- Has occurred on the Eyre Peninsula in SA (but has not been sighted in recent years)
- Has been reported in commercial crops in NSW in 2016 and eradication zones have been set up
- VIC has no anthracnose reports (any sightings should be reported to CropSafe)
- All above-ground parts of the lupin plant can be infected
- Yield losses can be up to 50 percent in susceptible varieties
- Severe infection can lead to plant death
- Variety resistance can reduce the impact from seed-borne infection
- Registered seed dressings and foliar fungicides are effective control measures.

Anthracnose, caused by the fungus *Colletotrichum lupini*, is a highly destructive disease of lupin crops that can lead to total crop loss in susceptible varieties if not managed. But, typically, it can be eradicated from a paddock, farm or region by using correct rotations and hygiene practices, such as growing non-lupin crops for several years.

This disease has occurred in broadacre lupin crops in South Australia's Eyre Peninsular region in the past, but has not been seen in recent years. Quarantine restrictions for importation of SA lupins into VIC and NSW were put in place in 1996. More information about VIC quarantine rules is available at: <u>http://agriculture.vic.gov.</u> <u>au/agriculture/horticulture/moving-plants-and-plant-products/moving-plants-withinvictoria/compliance-and-verification-agreements/lupin-anthracnose</u>

Lupin anthracnose permit requirements remain in place for used agricultural machinery, used packages and diagnostic samples.

Permit requirements regarding the movement of lupin seed and plants have been removed, although these items must still be certified. These pathways continue to be considered as posing a high risk for the entry, spread and establishment of this disease in Victoria.





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The following previously regulated articles no longer require certification:

- Grain or husks must be marketed as stock feed or for processing.
- Hay, straw or fodder must be marketed as stock feed or for processing.<sup>4</sup>

Anthracnose was reported in NSW crops in 2016 and eradication zones have been set up. More information is available at: <u>http://www.dpi.nsw.gov.au/biosecurity/plant/</u>recent-pest-arrivals/lupin-anthracnose

In recent years, use of resistant varieties, less sowing of infected seed and registration of foliar fungicides for anthracnose have reduced the impact of this disease across southern Australia.

While SA growers need to be wary of anthracnose from a marketing perspective, its risk does not typically affect crop management.

Continued improved management of anthracnose is expected to enable retention of lupin in crop sequences in disease susceptible areas and help to reduce reliance on nitrogen (N) fertilisers and fungicides in cereal phases of the rotation.

The anthracnose pathogen survives on lupin stubbles and can persist for up to two years in (or on) infected seed, which will produce infected seedlings.

These seedlings have lesions on the root, hypocotyl, cotyledons, leaf petioles or stems, which – in turn – create an abundance of spores.

Spores can be splashed on to surrounding plants by rain and have been shown to travel more than 100 metres to establish the disease in new crops.

It is important that disease-free seed is obtained from reputable sources. Standard hygiene practice should apply when dealing with equipment, material or people from infected states.

Anthracnose-infected seed can cause significant yield losses (of up to 50 percent in some WA trials) in all lupin varieties due to the early establishment of infection.<sup>5</sup> Southern region lupin crops can be affected to a similar extent by this disease.

The most distinctive symptoms of anthracnose are bending and twisting of stems, with a lesion in the crook of the bend. These are very noticeable at flowering.

Stem lesions are typically dark brown, with a pale pinkish-orange spore mass in the lesion. The stem can be completely girdled by lesions, or so weakened that it breaks. Both the main stem and lateral branches can be affected and close inspection will often show similar symptoms on leaves.

Pods develop lesions similar to those on stems and are often twisted and distorted. Infections at this stage can result in complete loss of pods, or production of infected seed.

Infected seed can appear symptomless, or can be malformed with discoloration, fungal mycelium or pink spores on the seed surface. Seed testing can detect presence and levels of infection.

#### Management of anthracnose

- » Use resistant varieties in high risk environments
- » Test seed for presence and levels of infection and use clean seed
- » Thiram (Group M3)-based seed dressing fungicides can reduce disease transmission
- » Mancozeb (Group M3) active is registered for foliar application
- » Under high disease pressure, foliar sprays are ideally applied at early podding on main stems and first order branches.<sup>6</sup>

4 Agriculture Victoria, Lupin Anthracnose, <u>http://agriculture.vic.gov.au/agriculture/horticulture/moving-plants-and-plant-products/moving-plants-within-victoria/compliance-and-verification-agreements/lupin-anthracnose</u>

5 Thomas, G (2004) Advanced management strategies for control of anthracnose and brown spot in lupins, GRDC Final Report, <a href="http://finalreports.grdc.com.au/DAW665">http://finalreports.grdc.com.au/DAW665</a>

6 DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing anthracnose in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/mycrop/</u> <u>diagnosing-anthracnose-narrow-leafed-lupins</u>



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As shown in Table 1, the narrow leafed lupin varieties PBA Bateman<sup>*b*</sup>, PBA Jurien<sup>*b*</sup>, PBA Barlock<sup>*b*</sup>, Mandelup<sup>*b*</sup> and Tanjil<sup>*b*</sup> are resistant to athracnose, along with the albus variety Amira<sup>*b*</sup>.

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Research has shown anthracnose resistance is most strongly expressed in stem tissue, offering good protection from the impact of seed-borne infection.

But resistant varieties can suffer significant yield losses from infection at the flowering and podding stages.<sup>7</sup>

In some years (at the request of marketers), a lupin 'anthracnose-free' segregation has been set up in the Eyre Peninsular region of SA for selected growers. This has enabled grain to be tested as free of anthracnose and eligible to be transported to approved markets in VIC and NSW. This has tended to occur in years of drought when feed demand exceeds supply in those states.

Anthracnose grain tests are the most common way to identify anthracnose freedom for marketing.

Paddock inspection for anthracnose freedom is usually the cheaper option per tonne of grain produced, but this is not available to lupin growers in some parts of the Eyre Peninsula.

To establish eligibility for paddock inspection, sowing seed must have been tested for anthracnose.

Certification requirements for lupin anthracnose were updated in Victoria in late 2015. For more information go to this link <u>http://agriculture.vic.gov.au/agriculture/horticulture/moving-plants-and-plant-products/moving-plants-within-victoria/compliance-and-verification-agreements/lupin-anthracnose</u>

Research has found fungicide seed dressings with the active ingredient thiram (at a rate of about 1.7-2 Litres/tonne seed) can reduce seed transmission of anthracnose by about 75 percent. Thiram gives poor control of Brown leaf spot, but can be safely used in conjunction with fungicides containing the Group 2 actives iprodione or procymidone for protection from both diseases.<sup>8</sup>

If seed testing shows zero anthracnose, use of a fungicide seed dressing is typically not needed.

Mancozeb (Group M3) is registered for foliar application to control anthracnose in lupin crops at rates of 1-2.2 kilograms per hectare.

Research trials in WA have found the optimum spray timing of foliar fungicide for this disease in lupin is before infection and at podding on first branches.<sup>9</sup>

This can be useful when more resistant varieties are not available or when lupin is grown in areas of high disease risk under high disease pressure.

Foliar fungicide application may also facilitate the production of higher yielding moderately resistant (MR) narrow leafed varieties (such as Mandelup<sup>(b)</sup>) in high yield potential, but high disease risk, areas.

Agronomic practices, such as stubble retention/sowing into standing stubble (except for into lupin stubble), avoiding sowing lupin following lupin and controlling volunteer lupin have been shown to reduce the spread of anthracnose from infected seed.

- 7 Thomas, G (2004) Advanced management strategies for control of anthracnose and brown spot in lupins, GRDC Final Report, <u>http://finalreports.ordc.com.au/DAW665</u>
- 8 Thomas, G (2004) Advanced management strategies for control of anthracnose and brown spot in lupins, GRDC Final Report, http://finalreports.grdc.com.au/DAW665
- 9 Thomas, G (2004) Advanced management strategies for control of anthracnose and brown spot in lupins, GRDC Final Report, http://finalreports.grdc.com.au/DAW665







### i) MORE INFORMATION

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GRDC 'Grain Legume Handbook': <u>https://grdc.com.au/</u> grainlegumehandbook

DPIRD-GRDC MyCrop: <u>https://www.</u> agric.wa.gov.au/mycrop



### 8.3 Brown leaf spot (Pleiochaeta setosa)



Figure 2: Brown leaf spot on narrow leafed lupin leaves. (SOURCE: GRDC Grain Legume Handbook)



**Figure 3:** *Brown leaf spot on pods.* (SOURCE: GRDC Grain Legume Handbook)

- Affects all lupin varieties
- Cotyledons, leaves, stems and pods can be infected
- Control tactics include rotations, resistant varieties, adequate crop nutrition and targeted fungicides
- Group 2 fungicide actives iprodione and procymidone-based seed dressing fungicides are registered for control and can reduce seedling infection.

Brown leaf spot (*Pleiochaeta setosa*) is a widespread and costly foliar disease of lupin crops.

All species are affected, including the commonly grown narrow leafed varieties Mandelup<sup> $\phi$ </sup>, PBA Barlock<sup> $\phi$ </sup>, PBA Jurien<sup> $\phi$ </sup> and new PBA Bateman<sup> $\phi$ </sup> and the albus variety Amira<sup> $\phi$ </sup>.

Paddocks previously sown to lupin will have *Pleiochaeta* spores in the soil and these can persist for several years, making crop rotation with non-host species an integral control strategy.





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Brown leaf spot infection occurs when spores are splashed by rain from the soil onto new lupin plants.

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Crop damage can increase at early seedling stage, when plant growth rates are slowed by colder environments, late sowing, poor nutrition, herbicide damage or unfavourable soil type. Seedling infection has been shown to have the biggest impact on grain yield.

Infected cotyledons develop dark brown spots, rapidly become yellow and drop off.

Leaves develop dark brown spots, often become net-like, distorted and small and then drop off prematurely.

Brown flecks may be evident on infected stems and occasionally large brown-black cankers develop that kill the stem above the infection point.

Pods, particularly those set closer to the ground, may be flecked or develop larger brown lesions. Stem and pod infection are usually associated with leaf infection in the upper canopy.

#### Management of Brown leaf spot

- » Rotate lupin paddocks to non-host crops for at least one year
- » Sow lupin into retained cereal stubble to reduce rain splash of soil-borne spores on to foliage
- >> Use agronomic practices that promote seedling vigour and canopy closure

   early sowing, adequate nutrition, care in herbicide use and higher seeding rates
- » Select more tolerant narrow leafed lupin varieties
- » Iprodione or procymidone-based seed dressing fungicides are effective.<sup>10</sup>

Seed dressing fungicides may be useful in high risk areas, such as on loamy and heavy soil types and where stubble is not retained, to reduce Brown leaf spot infection in seedlings.

But, on sandy soils, if stubble cover is high and there is no paddock history of Brown leaf spot, there is often no need to use a seed dressing.<sup>11</sup>

A potential agronomic issue for Brown leaf spot is weed control, with WA trials carried out in 2000-04 finding disease damage to leaves could increase with the use of the herbicide simazine (Group C).<sup>12</sup>

Glasshouse research in 2004-08 found Mandelup<sup>()</sup> infected with Brown leaf spot could tolerate commonly used post-emergent herbicides (with the actives diflufenican (Group F) and metribuzin (Group C) applied at registered label rates) without affecting plant growth, development or yield. It is advised that under low Brown leaf spot disease severity, these herbicides – alone or mixed with other actives – might increase disease severity and reduce yields.<sup>13</sup>

10 DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing brown spot in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-brown-spot-narrow-leafed-lupins</u>



<sup>11</sup> DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing brown spot in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/mycrop/</u> diagnosing-brown-spot-narrow-leafed-lupins

<sup>12</sup> Thomas, G (2004) Advanced management strategies for control of anthracnose and brown spot in lupins, GRDC Final Report, <u>http://</u> finalreports.grdc.com.au/DAW665

<sup>13</sup> Dhammu, H.S, MacLeod, W.J, Roberts, C, Payne, P.L.M, Antuono, M.F (2008) Interaction of brown leaf spot with post-emergent herbicides in narrow-leafed lupins, DAFWA, <u>http://www.lupins.org/fod/conference/2008/Agronom/\$2004/200Posted:\$200Ps20Psyne%20and%20M%20DAntuono.pdf</u>



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### i MORE INFORMATION

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DPIRD-GRDC MyCrop: <u>https://www.</u> agric.wa.gov.au/mycrop/diagnosingphomopsis-stem-and-pod-blightnarrow-leafed-lupins

DPIRD 'Lupinosis': <u>https://www.agric.</u> wa.gov.au/livestock-biosecurity/ lupinosis-sheep





Figure 4: Phomopsis symptons on lupin stubble. (SOURCE: DPIRD)



Figure 5: Phomopsis infection of narrow leafed lupin crops.

(SOURCE: W. Hawthorne)

- Phomopsis fungus infection can cause lupinosis in livestock
- Infects lupin stems, leaves, pods and seed and causes yield losses
- Narrow leafed varieties more susceptible than albus
- Control tactics include more resistant varieties and extending lupin crop sequences.

The major impact of phomopsis stem blight (*Phomopsis leptostromiformis*) and phomopsis pod blight (*Diaporthe toxica*) is production of a mycotoxin (*phomopsin*) as the fungus grows in mature lupin stems.

This can cause livestock sickness or death from lupinosis if grazing of infected stubble is poorly managed.

Crop symptoms of phomopsis typically appear on senescing lupin stems as darkpurplish lesions that bleach with age and contain black fruiting bodies. It can cause plants to lodge.



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Small black fruiting bodies develop on lupin stubble, often after summer rain, which stimulates growth of the fungus and the production of toxins and makes it dangerous for grazing.

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Re-infected seedlings in subsequent crops develop deep-yellow to brown, irregular shaped lesions on stems below the cotyledons. Severe lesions may girdle the stem and kill the plant.

Pod lesions can lead to infected seeds, which appear as either normal or are discolored light yellow to reddish-tan. Web-like grey mould of the fungus may be seen on the seed coat and inside the seed pod.



**Figure 6:** Dr Kurt Lindbeck, plant pathologist at the New South Wales Department of Primary Industries, says small, raised black fruiting structures within a lesion on a lupin plant or lupin stubbles are symptomatic of the disease phomopsis. (SOURCE: GRDC)



Figure 7: Phomopsis infection on lupin seed. (SOURCE: GRDC Grain Legume Handbook)

#### Management of phomopsis

- » Use more resistant varieties in high risk areas
- » Extend lupin phases in crop rotation planning
- » Destroy infected crop residues with burning or cultivation
- » Take care when grazing lupin stubbles in high risk areas
- » Remove stock from lupin stubbles when summer rain is imminent.<sup>14</sup>



<sup>14</sup> DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing phomopsis stem and pod blight in narrow-leafed lupins, <u>https://www.aqric.wa.gov.au/mycrop/diagnosing-phomopsis-stem-and-pod-blight-narrow-leafed-lupins</u>



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Narrow leafed lupin tends to be more prone to phomopsis stem and pod blight than albus lupin. But PBA Bateman<sup>*b*</sup>, PBA Jurien<sup>*b*</sup>, PBA Barlock<sup>*b*</sup>, Jindalee, PBA Gunyidi<sup>*b*</sup>, Wonga and Mandelup<sup>*b*</sup> have moderate resistance to both stem and pod infection.

If weather conditions favor the pathogen, including prolonged rainfall or high humidity in late spring and summer, stubble can develop some toxicity and require care with grazing. But current commercial varieties do not produce highly toxic stubbles.<sup>15</sup>

Increasing the breaks between lupin crops allows weathering and breakdown of infected stubble, reducing disease inoculum.

### 8.5 Cucumber mosaic virus (CMV)



**Figure 8:** Cucumber mosaic virus is seed and aphid-borne and narrow leafed lupin varieties are more susceptible than albus lines.

(SOURCE: DPIRD)

- Seed and aphid-borne
- Spread by sowing infected seed and via aphid vectors
- Seed testing for infection is advised
- Neonicotinoid-based insecticide can be used on seed
- Suppressing aphid transmission is a key management tactic.

Infected seed is the most common source of Cucumber mosaic virus (CMV) incidence in lupin crops. Narrow leafed varieties are more susceptible than albus lines.

Lupin and lentil crops in south eastern Australia tested between 2000 and 2010 were the most likely of all crops tested to be infected with this disease.

A seed infection level of 1 percent means one plant in every 100 plants will typically be virus-infected and these will tend to be randomly distributed across the paddock.

Secondary infection occurs by aphids, which acquire the virus from primary infected plants (or weeds, clover or other pulse crops) and spread it to healthy crops.

Aphid species that spread CMV include Green peach aphid (*Myzus persicae*), Blue green aphid (*Acyrthosiphon kondoi*) and Cowpea aphid (*Aphis craccivora*) that colonise lupin crops.

### i) MORE INFORMATION

GRDC 'Fact Sheet – Resistance Management Strategy for the Green Peach Aphid in Australian Grains': <u>www.grdc.com.au/</u> <u>GPAResistanceStrategy</u>

GRDC 'Back Pocket Guide – Crop Aphids': <u>https://grdc.com.au/</u> <u>CropAphidsBackPocketGuide</u>

DPIRD 'Cucumber Mosaic Virus': https://www.agric.wa.gov.au/grainsresearch-development/cucumbermosaic-virus-narrow-leafed-lupins



<sup>15</sup> DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing phomopsis stem and pod blight in narrow-leafed lupins, <u>https://www.aqric.wa.qov.au/mycrop/diagnosing-phomopsis-stem-and-pod-blight-narrow-leafed-lupins</u>



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The disease is also spread by migrants of common non-lupin colonising aphid species, especially Oat aphid (*Rhopalosiphum padi*) and Turnip aphid (*Lipaphis erysime*).

CMV infection causes lupin leaves to become pale, bunched and down-curled with faint mosaic patterns.

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It can severely stunt plant growth and the earlier a plant becomes infected, the fewer the pods set, the smaller the size of seed produced and the lower the crop yield.

With late infections, symptoms tend to be restricted to tip leaves.

As shown in Table 3, yield losses from CMV can be as high as 60 percent when all plants in a crop become infected. Losses are greatest when seed with more than 1 percent infection is sown, aphids arrive early and widespread plant infection occurs.<sup>16</sup>

**Table 3:** Effect of sowing CMV-infected seed on yield and subsequent seed

 transmission (data from Western Australian field trials).<sup>17</sup>

Scenario	1	2	3	4
Initial CMV seed infection level	5%	0.5%	5%	0.5%
Aphid arrival	Early	Early	Very late	Very late
Final crop infection	89—95%	34—53%	1—2%	0.1%
Yield loss	36—53%	ns	ns	ns
Harvested CMV seed	12—13%	7%	0.6%	0.1—0.2%

infection level

NOTE: ns=yield impact is not statistically significant

#### Management of CMV

- » Grow virus resistant varieties
- » Sow tested seed with virus levels less than 0.1-0.5 percent
- » Eliminate weeds and self-sown pulses for aphid and disease control
- » Monitor and control aphids, especially during early crop growth
- » Rotate lupin crops with cereals to break disease cycles
- » If necessary, use seed treatment containing neonicotinoidbased insecticide
- » In-crop insecticides have shown to be ineffective.<sup>18</sup>

Lupin varieties differ in rates of susceptibility to aphid colonisation and aphid-borne viruses, such as CMV.

Further information about resistance ratings to this and other viruses can be found at this link: <u>https://grdc.com.au/resources-and-publications/all-publications/</u>publications/2016/12/sa-sowingguide2017

Moderately resistant narrow leafed lupin varieties include PBA Bateman<sup>*b*</sup>, PBA Jurien<sup>*b*</sup>, PBA Barlock<sup>*b*</sup>, PBA Gunyidi<sup>*b*</sup>, Jenabillup<sup>*b*</sup> and Wonga.

Sowing healthy lupin seed is key to managing CMV in lupin and samples can be sent to commercial testing services, including DPIRD's Diagnostic Laboratory Services (DDLS)-Plant Pathology, to test infection levels.

- 17 DPIRD (2016) Cucumber mosaic virus in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/grains-research-development/cucumber-mosaic-virus-narrow-leafed-lupins?page=0%2C1</u>
- 18 DPIRD (2016) Cucumber mosaic virus in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/grains-research-development/cucumber-mosaic-virus-narrow-leafed-lupins?page=0%2C1</u>



<sup>16</sup> DPIRD (2016) Cucumber mosaic virus in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/grains-research-development/cucumber-mosaic-virus-narrow-leafed-lupins?page=0%2C1</u>



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In low-risk areas of the southern region, it is advisable to sow seed with less than 0.5 percent infection to reduce risk of yield loss in 'typical' seasons.

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Seed infection of less than 0.1 percent (shown as a zero result from a 1000 seed test) is recommended for grain crops in high risk areas and for seed certification crops in any rainfall zone. But it is advised that the outcome of sowing seed infected with a range of levels of CMV will vary significantly from year to year and site to site.<sup>19</sup>

Sowing seed with a high level of infection, coupled with early arrival of aphids, can initiate early epidemics of CMV that can result in high disease incidence, reduced yield and increased infection in harvested seed.

When there is a dry start to the growing season, sowing seed with a high level of infection can result in minimal yield loss and reduction in infection levels in harvested seed. The aphids arrive much later, resulting in a much reduced CMV spread.



**Figure 9:** Cucumber mosaic virus can lead to stunted, bunched plants with down-curled leaves, as shown on left.

(SOURCE: GRDC)

Seed dressing insecticides containing the active neonicotinoid have been found to help prevent crops from early feeding of aphids and can stop the infection of crops from viruses.

Agronomic practices such as sowing early into retained stubble, away from neighboring lupin crops, at high seeding rates and using narrow row spacing will promote early crop canopy coverage and deter aphids from landing.

This will shade over the seed-infected and early infected plants, denying aphids access to the crop.

Maximising weed control will also reduce the spread of CMV from lupin to weeds and from weeds back to lupin.

Research in WA has found insecticides applied in-crop crops are ineffective at controlling  $\mathrm{CMV}^{20}$ 

- 19 DPIRD (2016) Cucumber mosaic virus in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/grains-research-development/cucumber-mosaic-virus-narrow-leafed-lupins?page=0%2C1</u>
- 20 DPIRD (2016) Cucumber mosaic virus in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/grains-research-development/cucumber-mosaic-virus-narrow-leafed-lupins?page=0%2C1</u>





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### i MORE INFORMATION

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GRDC 'Grains Legume Handbook': <u>https://grdc.com.au/</u> grainlegumehandbook

DPIRD 'Bean Yellow Mosaic Virus': https://www.agric.wa.gov.au/lupins/ bean-yellow-mosaic-virus-lupins

### 8.6 Bean yellow mosaic virus (BYMV)



**Figure 10:** When Bean yellow mosaic virus affects a lupin plant, the youngest growth can bend over and cause a 'shepherd's crook' appearance. (SOURCE: DPIRD)

- Spread by aphid species that colonise lupin
- Can be seed-borne in albus varieties (not narrow leafed lines)
- Crop yield losses can be up to 80 percent if left unchecked
- Late summer and early autumn rain can increase spread
- Integrated disease management based on agronomic practices is needed
- Test for and sow virus-free seed.<sup>21</sup>

Bean yellow mosaic virus (BYMV) can be a serious disease if found in narrow leafed lupin crops in some years and situations and not managed. However, pulse crop surveys during the past 10 years in Victoria, SA and NSW indicate it is typically a minor issue.

Disease risk is typically highest in seasons with high summer/autumn rainfall that promotes early build-up and migration of aphids that carry BYMV.

Crops neighboring clover-based pastures, or containing clover/weeds, are at the greatest risk of infection.

If disease is present, there are two common strains that affect southern region lupin crops. The necrotic strain (BYMV-N) kills the infected plant and the less abundant non-necrotic (BYMV-NN) strain causes stunting without killing the plant.

DPIRD has a comprehensive guide to diagnosing BYMV at this link: <u>https://www.</u> agric.wa.gov.au/mycrop/diagnosing-bean-yellow-mosaic-virus-non-necrotic-narrowleafed-lupins<sup>22</sup>



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<sup>21</sup> DPIRD (2016) Management of aphids in Western Australian lupin crops, <u>https://www.agric.wa.gov.au/grains-research-development/</u> management-aphids-western-australian-lupin-crops

<sup>22</sup> DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing Bean yellow mosaic virus – non necrotic in narrow-leafed lupins, <u>https://</u> www.aqric.wa.gov.au/mycrop/diagnosing-bean-yellow-mosaic-virus-non-necrotic-narrow-leafed-lupins



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BYMV-N symptoms include:

- » Occurs before pod set
- » Necrotic streaking of the youngest portion of the shoot
- » This bends over, causing a shepherd's crook appearance
- » The growing tip dies
- » Leaves become pale, wilt and fall off
- » Necrotic streaking and blackening spread across the stem
- » Fast plant death without seed production.23

BYMV-NN symptoms include:

- » Occurs after pod set and is rare
- » Virus is slower to spread
- » Stunted pale plants
- » Deformed and often fleshy leaves
- » Pods blacken and fail to fill while the rest of the plant grows normally (known as black pod syndrome).<sup>24</sup>

#### Management of BYMV

- » Promote early crop canopy coverage sow early, use high seeding rates and narrow row spacing
- » Direct drill into retained stubble groundcover reduces aphid landing
- » Rotate lupin with non-host crops
- » Ensure good weed control
- » Insecticides applied in-crop are ineffective to control BYMV.<sup>25</sup>

There is typically only a brief period between initial BWYV symptoms appearing in young lupin crops and plant death.

This means incoming aphids can only acquire the virus from infected plants for one to two weeks and infection levels decline rapidly with increasing distance into the crop.

Management of this virus centres on agronomic practices that:

- » Eliminate clover/weed regrowth under lupin crops
- » Avoid sowing adjacent to clover based pastures
- » Deter aphid landing by reducing bare ground exposure.

This can be achieved by tactics such as promoting early canopy development, sowing into retained stubbles, using high seeding rates and adopting narrow row spacing.

High plant densities will tend to dilute the proportion of plants infected and increase compensatory growth of healthy plants.

Sowing a non-host crop (for example, a cereal) or a border strip between crops and adjacent pasture can also be effective, as incoming aphids lose the virus when they probe the non-host. This helps to reduce spread into the crop from an external source.<sup>26</sup>

24 DPIRD (2016) Bean Yellow mosaic virus in lupins, https://www.agric.wa.gov.au/lupins/bean-yellow-mosaic-virus-lupins

26 DPIRD (2016) Bean Yellow mosaic virus in lupins, https://www.agric.wa.gov.au/lupins/bean-yellow-mosaic-virus-lupins



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<sup>23</sup> DPIRD (2016) Bean Yellow mosaic virus in lupins, <u>https://www.agric.wa.gov.au/lupins/bean-yellow-mosaic-virus-lupins</u>

<sup>25</sup> DPIRD (2016) Bean Yellow mosaic virus in lupins, <u>https://www.agric.wa.gov.au/lupins/bean-yellow-mosaic-virus-lupins</u>



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DPIRD-GRDC MyCrop: <u>https://www.</u> agric.wa.gov.au/lupins/lupin-foliardiseases-diagnosis-and-management

DPIRD-GRDC MyCrop 'Sclerotinia Collar Rot': <u>www.agric.wa.gov.au/</u> <u>mycrop/diagnosing-sclerotinia-collar-</u> <u>rot-narrow-leafed-lupins</u> 8.7 Sclerotinia stem and collar rot (Sclerotinia sclerotiorum, Sclerotinia minor)



**Figure 11:** Sclerotinia stem rot is an increasing problem in Australian lupin crops and is characterised by fungal growth and sclerote on the stem and pods.

(SOURCE: GRDC Grain Legume Handbook)

- Sclerotinia stem rot is an increasing problem
- It is most common in high rainfall areas
- It usually affects plants after flowering in warm and damp conditions
- Sclerotinia collar rot is less prevalent but can be an issue in canola-lupin rotations
- Outbreaks are sporadic and typically yield losses are low
- In severe cases, sclerotia become mixed with harvested seed and incurs grain grading costs.

Incidence of sclerotinia stem rot (*Sclerotinia sclerotiorum*) has increased in recent years in the southern region, mostly as a result of expanded canola plantings.

In lupin crops, it tends to occur during flowering when ascospores infect petals.

Under constant humid and wet weather, infected petals fall and lodge in branches and infect stems and pods.

It can take two or three weeks for in-crop symptoms to be seen.

Sclerotinia stem rot symptoms include lesions in the upper half of the main stem, branches and on flowers and pods.

The fungus produces a white cottony-looking growth that girdles the stem, causing the plant parts above the lesion to wilt and die.

Individual pods or complete flower spikes can be completely covered by white fungal growth, which produces hard black sclerotia (of 2-8 mm in diameter).

Stems become bleached looking and infected plants stand out from the rest of the crop. The lifecycle of sclerotinia is illustrated in Figure 3.



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### Figure 12: Sclerotinia sclerotiorum disease cycle.

(SOURCE: DPIRD)

In cases of sclerotinia collar rot (*Sclerotinia minor*), lesions and fluffy white growth appear on stems just above ground level and contain small black fruiting bodies called sclerotia.

Researchers are investigating the impact of both forms of sclerotinia on lupin production and possible interactions with anthracnose control (especially fungicide application) in WA.

Lupin infected with sclerotinia can have lower yield due to plant death. In severe cases, grain requires grading after harvest to remove sclerotia.

Disease management can be difficult, as sclerotia can survive in the soil for many years.  $^{\rm 27}$ 

#### Management of sclerotinia

- » Rotate lupin crops with non-host species (cereals)
- » Avoid sowing lupin in close rotation with other broadleaf crops, such as canola
- » Control broadleaf weeds during the rotation
- » Foliar fungicides are not registered for sclerotinia in lupin crops.

Crop rotation with non-host species, such as cereals, and extended breaks between lupin and canola crops can help to break the sclerotinia disease cycle.

There are no foliar fungicides currently registered for treatment of sclerotinia in lupin crops.



<sup>27</sup> Thomas, G, Beard, C (2015) Mingenew Irwin Group Presentation, <u>http://www.mig.org.au/author/zoe/page/3/</u>



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Primary risk factors for disease in susceptible areas include:

» Presence of sclerotinia in paddock or neighbouring paddock from previous sclerotinia infection in lupin or canola (or other broadleaf crop/pasture) within the past three or four years

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- » Medium-high rainfall areas and/or seasons with wet springs
- » Densely growing crops on heavier soil types that maintain moisture longer and create a humid environment favoured by the pathogen.<sup>28</sup>

It is recommended to avoid sowing lupin in close rotation with other broadleaf crop species, such as canola, especially where these are the main break crops of choice.

Cereals are non-hosts and provide the most effective disease break, although sclerotia can survive for several years.

WA researchers are investigating the use in lupin crops of fungicide products registered for sclerotinia stem rot in canola in WA.

They are also developing a forecasting tool for sclerotinia outbreaks and incidence.

Trials have, to date, found no significant differences in lupin variety resistance to sclerotinia, as shown in Figure  $4.^{\rm 29}$ 



Sclerotinia lesion length on cut stems (7 days after inoculation)

**Figure 13:** Sclerotinia lesion length on cut stems (7 days after inoculation). (SOURCE: DPIRD)



<sup>28</sup> DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing sclerotinia collar rot in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/</u> mycrop/diagnosing-sclerotinia-collar-rot-narrow-leafed-lupins

<sup>29</sup> Thomas, G, Beard, C (2015) Mingenew Irwin Group Presentation, <u>http://www.mig.org.au/author/zoe/page/3/</u>



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### 8.8 Minor foliar diseases in southern region lupin crops

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Disease	Location	Symptoms	Management	Useful resources
Grey leaf spot (Stemphylium botryosum)	Leaves, stems, pods	Brown semi-circular or circular lesions/spots on leaves that can expand and become ash-grey. Brown 'pockmark' lesions on stems and pods. Premature or complete defoliation can occur.	Disease uncommon and rarely economically damaging. Current varieties carry effective genes for resistance.	https://www.agric.wa.gov. au/lupins/lupin-foliar- diseases-diagnosis-and- management
Cladosporium leaf spot (Cladosporium sp.)	Leaves, flowers	Dark grey circular spots on flowers and leaves.	Incidence and yield impact rare. No specific control measures, except crop rotations.	https://www.agric.wa.gov. au/lupins/lupin-foliar- diseases-diagnosis-and- management
Grey mould ( <i>Botrytis cinerea</i> )	Leaves, stems, pods	Lesions on flowers, stems and pods, grey fuzzy mould that may contain sclerotia. May be more common in albus than narrow leafed lupin.	Incidence and yield damage rare, no specific control measures except crop rotations.	https://www.agric.wa.gov. au/mycrop/diagnosing- grey-mould-narrow- leafed-lupins_and_https:// www.agric.wa.gov. au/lupins/lupin-foliar- diseases-diagnosis-and- management
Powdery mildew ( <i>Erysiphe polygoni</i> )	Leaves, stems, pods	White powdery growth on leaves, stems and pods.	Affects all species but serious crop damage has not been reported. No specific management strategies needed, except crop rotations.	https://www.agric.wa.gov. au/lupins/lupin-foliar- diseases-diagnosis- and-management

### (i) MORE INFORMATION

DPIRD-GRDC MyCrop: <u>https://www.</u> agric.wa.gov.au/lupin-diagnostic-tool

GRDC 'Grains Legume Handbook': <u>https://grdc.com.au/</u> grainlegumehandbook





### i) MORE INFORMATION

GRDC 'Fact Sheet Pre-harvest Herbicide Use': <u>www.grdc.com.au/</u> <u>GRDC-FS-PreHarvestHerbicide</u>

GRDC 'Fact Sheet Late Season Herbicide Use': <u>http://elibrary.grdc.</u> <u>com.au/ark%21%2133517/x4vcv2x/</u> <u>wk5myft</u>

DPIRD 'Fact Sheet Weed Control in Mature Crops and Desiccation': https://www.agric.wa.gov.au/grains/ crop-weeds-stop-weed-seedset?page=0%2C5#smartpaging\_toc\_ p5\_s4\_h3

DPIRD 'Crop Weeds': <u>https://</u> www.agric.wa.gov.au/grains/ crop-weeds-stop-weed-seedset?page=0%2C3#smartpaging\_toc\_ p3\_s1\_h3

Pulse Australia 'Australian Pulse Bulletin — Desiccation and Croptopping in Pulses': <u>http://www.</u> <u>pulseaus.com.au/growing-pulses/</u> <u>publications/desiccation-and-</u> croptopping

# Desiccation, crop-topping and green/brown manuring

### 9.1 Overview

Desiccation and crop-topping involve strategic application of a registered herbicide close to the final maturity of the lupin crop. These tactics can be used separately or in combination to meet different objectives on individual properties.

Desiccation (typically coupled with windrowing/swathing) terminates crop growth, regardless of the development stage of weeds. The aim is to encourage even ripening of crops and minimal infestations of green weeds for ease of harvest.

Desiccation is often not warranted in southern region narrow leafed lupin crops because these naturally tend to ripen rapidly and evenly and there can be little to be gained by applying a desiccant. But it may be required in manganese (Mn) deficient crops that do not ripen, or where weeds have become a harvest problem.

Desiccation can be an effective strategy in albus lupin crops in some areas and some seasons to dry out wild radish (*Raphanus raphanistrum L.*) seed prior to harvest and to prevent harvest delays.

Crop-topping is the application of a non-selective knockdown herbicide close to crop maturity aimed at preventing seed set in weeds (mainly grasses), controlling in-crop weed escapees and lowering paddock weed seedbanks.

This approach broadens weed management options and strengthens the role of lupin and other pulses in crop rotations for southern region farming systems.

For crop-topping, timing is critical and best results are achieved when it is matched to weed seed development stage – irrespective of the development stage of the crop.

Narrow leafed lupin can suffer substantial yield losses if the crop has not reached physiological maturity at or before the timing of crop-topping.

Breeding and variety development by Pulse Breeding Australia (PBA) has produced earlier maturing narrow leafed varieties, such as PBA Bateman<sup>¢</sup>, PBA Jurien<sup>¢</sup>, PBA Barlock<sup>¢</sup> and PBA Gunyidi<sup>¢</sup>, that are far better suited to this system than older varieties.

Typically, albus lupin mature too late for crop-topping to be effective and desiccation is rarely needed to even-up ripening of these varieties.<sup>1</sup>

As with all herbicide use, the GRDC advises strict adherence to product label registrations, rates and withholding periods when undertaking desiccation or croptopping in the lupin crop.

Harvest can start as soon as the harvest withholding period has been observed.

Late season herbicide application increases the risks of detectable herbicide residues in harvested grain and it is important to know the maximum residue limits (MRL) for lupin.

It is recommended to harvest crop-topped lupin as soon as possible (mindful of any withholding periods) if weed seed capture is an objective.

Pulse Australia (2016) Australian Pulse Bulletin, Desiccation and Crop-topping in Pulses, <a href="http://www.pulseaus.com.au/growing-pulses/publications/desiccation-and-croptopping">http://www.pulseaus.com.au/growing-pulses/publications/desiccation-and-croptopping</a>





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Crop-topping increases the speed that weeds die-off and drop their seeds on the ground, making capture in chaff carts, bales of straw, windrows or with seed destruction technology important.

It is advised to test vigour and germination of lupin seed from crop-topped paddocks for planting the following year, or avoid using this seed altogether.

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Using lupin crops for green or brown manuring can be another strategy for reducing weed burdens in cropping systems, with added benefits of improving soil fertility and soil organic matter.

But there are significant risks of wind and water erosion from green manuring that require close consideration.



### 9.2 Windrowing/swathing

**Figure 1:** Pictures show the pod and seed development of narrow leafed lupin, and embryos from those pods, at various stages in their development. The coloured bars show changes in the colours of the pod, seed and embryo.

(SOURCE: DPIRD)

Windrowing, or swathing, of lupin involves cutting the crop and laying it in a windrow. It is carried out when the seed is close to physiological maturity, before desiccation, to help manage risks of grain shattering and spoilage.

This tactic is suitable for narrow leafed and albus types and also provides benefits of: avoiding grain contamination with green material (such as late germinating weeds); reducing potential grain storage problems (due to high moisture levels in weed seeds); helping to manage crops that are ripening unevenly; and reducing weed seed set as part of a harvest weed seed control program.

Timing the windrowing operation is vital to its success and is based on an assessment of seed maturity in the order of pods (primary to final). This involves checking the cotyledon (kernel) colour, which will often be green for seeds found in pods on the lateral branches and yellow for those found on the main stem.

Typically, windrowing of lupin crops can start when the average moisture content of all seed is 65 percent. This tends to occur at the start of leaf drop, when the stems and leaves of the plant are light green-yellow.

It is recommended to avoid windrowing if seed moisture content falls below 50 percent, as the risk of yield loss through pod drop during the operation and while the crop is in the windrow increases. It is advised to cut the crop 10-20 cm above the ground.





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Windrows will typically be ready to harvest about 10-30 days after cutting. Harvester settings are important to minimise potential yield loss from pod drop or shattering.

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For albus lupin varieties, it is important to avoid windrowing too early, as immature seeds can shrivel when dry and lead to lower grain quality. For narrow leafed varieties, it is advised to avoid cutting crops if there are prolonged dry conditions at harvest, as this can cause higher levels of pod drop. See Chapter 10 for more information about harvesting lupin crops.



**Figure 2:** Pod wall, seed coat and cotyledon colour of narrow leafed lupin at the correct stage of maturity to windrow.

(SOURCE: NSWAg Pulse Point)



**Figure 3:** Seed coat and cotyledon colour of albus lupin at the earliest stage at which they should be windrowed.

(SOURCE: NSWAg Pulse Point)



**Figure 4:** Summary of lupin growth stage and when to undertake windrowing. (SOURCE: DPIRD)





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# 9.3 Decision-making for desiccation (with windrowing/ swathing)

Crop desiccation and windrowing/swathing are predominantly harvest aids. But this practice can provide significant weed management benefits in some conditions and seasons, especially by lowering the weed seedbank.<sup>2</sup>

The main reasons for using desiccation, with windrowing/swathing, in lupin crops include:

- » Accelerating or evening-up crop ripening for ease of harvesting
- » Improving harvest speed and efficiency
- » Minimising grain loss from shattering or lodging in prone areas
- » Improving grain quality
- » Reducing risks of weather damage
- » Conserving soil moisture for the next crops
- » Stopping seed set in late season weeds
- » Preventing seed set of annual ryegrass (Lolium rigidum)
- » Helping manage any herbicide resistance issues.<sup>3</sup>

### 9.4 Decision-making for crop-topping

Crop-topping can be a valuable tool to reduce the weed seedbank to enable early dry sowing in a low weed burden paddock the following year, rather than waiting for sufficient rain to germinate weeds for a knockdown herbicide application.

Crop-topping in lupin helps manage weeds, especially grasses, that are often difficult to control in cereal and canola crops and is a useful part of a longer-term herbicide resistance management plan.

Key reasons for crop-topping lupin crops in the southern region include to:

- » Minimise production of viable weed seeds (especially annual ryegrass)
- » Optimise grain yields
- » Even-up crop maturity
- » Help manage any herbicide resistance issues.<sup>4</sup>



<sup>2</sup> DPIRD (2016) Crop Weeds: Stop weed seed set, In-crop Weed Management for Seed Set Control, <u>https://www.aqric.wa.gov.au/qrains/</u> crop-weeds-stop-weed-seed-set?page=0%2C5#smartpaging\_toc\_p5\_s4\_h3

<sup>3</sup> DPIRD (2016) Crop Weeds: Stop weed seed set, In-crop Weed Management for Seed Set Control, <u>https://www.aqric.wa.gov.au/qrains/</u> crop-weeds-stop-weed-seed-set?page=0%2C5#smartpaging\_toc\_p5\_s4\_h3

DPIRD (2016) Crop Topping Pulse Crops, <u>https://www.agric.wa.gov.au/lupins/crop-topping-pulse-crops</u>



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GRDC 'Fact Sheet Pre-harvest Herbicide Use': <u>www.grdc.com.au/</u> <u>GRDC-FS-PreHarvestHerbicide</u>

DPIRD 'Crop-topping Pulse Crops': https://www.agric.wa.gov.au/lupins/ crop-topping-pulse-crops

Australian Pesticides and Veterinary Medicines Authority: www.apvma.gov.au

# 9.5 Products and timing for crop-topping and desiccation

Crop-topping lupin with paraquat (Group L) can be effective to control annual ryegrass in conducive seasons.

This is an accepted practice in many parts of the southern region to help control high annual ryegrass burdens in preparation for potentially dry sowing wheat crops the following year.

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Crop-topping is best carried out when lupin plants have lost 80-90 percent of leaves (including all brown leaves still attached to the plant) and grass weed species are at the 'flowering' to 'soft dough' stage. Early maturing narrow leafed varieties, including PBA Bateman<sup>¢</sup>, PBA Jurien<sup>¢</sup>, PBA Barlock<sup>¢</sup>, PBA Gunyidi<sup>¢</sup> and Mandelup<sup>¢</sup>, tend to reach this stage seven to 10 days before later maturing, older lines, such as Tanjil<sup>¢,5</sup>

Diquat (Group L) is registered for desiccation in lupin crops in the southern region.

It is recommended desiccation or crop-topping tactics are carried out as part of an integrated weed management (IWM) program that might also include cutting crops for hay, green or brown manuring and harvest weed seed control (HWSC) tactics.

Typically, narrow leafed lupin crops in low to medium rainfall areas tend to ripen quickly and evenly and often desiccation is not warranted.

Success of desiccation and crop-topping relies on seasonal conditions, especially in high rainfall areas.

If there is a prolonged wet spring, this will tend to extend lupin flowering and podding and annual ryegrass can often develop too quickly (past the ideal stage) before the crop is ready to treat with herbicides.

Desiccation should be avoided, or held off, if heavy rain is forecast soon after spraying – as yield loss can be significant due to weakened pods.

It is recommended to harvest promptly when lupin grain reaches more than 14 percent moisture to minimise crop losses.

Guidelines for assessing annual ryegrass development stage for desiccation and crop-topping includes:

- » Pull seed off from the middle of the seed head
- » Squeeze the seed between your fingers
- » If there is just sappy liquid the seed is 'watery ripe'
- » If there is milky, white liquid this is the 'milk stage'
- » Sap thickness denotes early, middle and late milk stages
- » If there is sap that is sludgy but still soft and like dough this is the 'dough stage'
- » When there is very limited moisture this is the 'firm or hard dough stage'
- » If the seed hardly compresses and is a yellow/brown color this is near 'ripening'
- » After this, it will be too late to get good control.<sup>6</sup>

Research has shown that the yields of lupin and other pulse crops are typically not reduced if crop-topping is delayed until seeds in the top pods of lupin are 75 percent or more of full size.<sup>7</sup>

But there may need to be a balance between optimal timing for effective annual ryegrass control (which is often earlier) and potential lupin grain yield loss.



<sup>5</sup> DPIRD (2016) Crop Topping Pulse Crops, <u>https://www.agric.wa.gov.au/lupins/crop-topping-pulse-crops</u>

<sup>6</sup> DPIRD (2016) Crop Topping Pulse Crops, <u>https://www.agric.wa.gov.au/lupins/crop-topping-pulse-crops</u>

<sup>7</sup> GRDC (2015) Fact Sheet – Pre-harvest Herbicide Use, <u>www.grdc.com.au/GRDC-FS-PreHarvestHerbicide</u>



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It is advised not to desiccate or crop-top lupin that will have seed retained for subsequent planting, as this has potential to adversely affect seed quality due to uneven ripening.<sup>8</sup>

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### 9.5.1 Paraquat use

Paraquat has been found to work well when integrated in cropping systems in the southern region, as it has a wider application window for timing of crop-topping to control annual ryegrass. Another benefit is that it will typically hasten the time to harvest.

For application to control annual ryegrass, the last seed heads at the bottom of the plant can be emerged and most heads should be at - or just past - flowering (not yet haying-off).

Crop-topping with paraquat has been shown to significantly reduce the number of annual ryegrass plants emerging in the following wheat crop.

Guidelines for using paraquat (at 250 grams/Litre) on lupin crops for croptopping include:

- » Rates of 400–800 millilitres per hectare
- » Use highest registered rate
- » Spray volume of 30–100 L water/ha
- » Aim for medium droplets
- » Annual ryegrass seeds heads should be emerged and at, or just past, flowering and not yet haying-off
- » Harvest withholding period is seven days after application
- » Harvest as soon as practicable once grain is at 14 percent moisture.<sup>9</sup>

### 9.5.2 Diquat use

Diquat is useful for desiccation of lupin crops and registered for use as soon as the crop has reached full maturity.

It can accelerate crop drying and reduce seed moisture levels to reduce grain drying costs, risks of harvesting delays and weather risks at this time of year.

Guidelines for using diquat (at 200 g/L) on lupin crops for desiccation include:

- » Rates of 2-3 L/ha
- » Application by boomspray, hand lead or aeroplane
- » Minimum spray volume of 100 L/ha recommended for ground application
- Spray volume of 30–60 L/ha recommended for aerial application
- » Aim for fine-medium spray quality
- » Flat fan nozzle is preferred on ground
- » Aim to minimise drift from any aerial application
- » Apply when crop has reached full maturity
- » No specified withholding period.<sup>10</sup>



<sup>8</sup> DPIRD (2016) Crop Topping Pulse Crops, <u>https://www.agric.wa.gov.au/lupins/crop-topping-pulse-crops</u>

<sup>9</sup> Pulse Australia (2016) Australian Pulse Bulletin, Desiccation and Crop-topping in Pulses, <u>http://www.pulseaus.com.au/growing-pulses</u>, <u>publications/desiccation-and-croptopping</u>

<sup>10</sup> Pulse Australia (2016) Australian Pulse Bulletin, Desiccation and Crop-topping in Pulses, <u>http://www.pulseaus.com.au/growing-pulses/publications/desiccation-and-croptopping</u>



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DPIRD 'Green Manuring': https://www.agric.wa.gov.au/grains/ crop-weeds-stop-weed-seedset?page=0%2C3#smartpaging\_toc\_ p3\_s1\_h3

DPIRD 'Carbon Farming Fact Sheet Green and Brown Manuring': <u>https://www.agric.wa.gov.au/carbon-farming/carbon-farming-fact-sheet-green-and-brown-manuring</u>

GRDC 'Fact Sheet – Manuring of Pulse Crops': <u>https://grdc.com.au/</u> <u>Resources/Factsheets/2013/09/</u> <u>Manuring-of-Pulse-Crops</u>

DPIRD 'Brown Manuring': https://www.agric.wa.gov.au/grains/ crop-weeds-stop-weed-seedset?page=0%2C3#smartpaging\_toc\_ p3\_s1\_h3



### 9.6 Green manuring of lupin

This tactic involves growing a crop for the specific purpose of turning it into the soil when green in spring, using cultivation, with the aim of boosting soil organic matter content and reducing weed burdens.

Green manuring is not commonly used in the southern region and a significant risk of wind and water erosion is associated with this practice that requires close consideration.

The green manuring process requires good management and timing of cultivation and depends on seasonal conditions.

### 9.7 Brown manuring of lupin

Brown manuring (BM) is a 'no-till' version of green manuring that uses a non-selective herbicide to desiccate the crop (and weeds) at flowering.

It is rarely practiced in the southern region due to high risks of water and wind erosion.

Brown manuring means crop plant residues remain standing, which can be a preferred option in some areas to green manuring – especially on lighter soils that are prone to erosion.

Research in the southern region found a crop production system that included BM of legumes in the rotation could be as profitable as continuous cropping.  $^{11}$ 

In practice, the preferred option for any legume crop used for BM in the southern region tends to be vetch due to its versatility for a range of soil types.<sup>12</sup>

12 Patterson, R.A. (2014) GRDC Grains Research Update Paper 'Brown manure as a farm risk strategy', <u>https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/02/Brown-manure-as-a-farm-risk-strategy-a-whole-farm-perspective</u>



<sup>11</sup> Patterson, R.A (2014) GRDC Grains Research Update Paper 'Brown manure as a farm risk strategy', <u>https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/02/Brown-manure-as-a-farm-risk-strategy-a-whole-farm-perspective</u>



### i) MORE INFORMATION

DPIRD 'Lupins': <u>https://www.agric.</u> <u>wa.gov.au/lupins</u> and <u>https://</u> www.agric.wa.gov.au/lupins/ lupin-essentials-%E2%80%93growing-successful-lupincrop?page=0%2C4#smartpaging\_ toc\_p4\_s2\_h2

# Harvest

### 10.1 Overview

Modern lupin breeding has focused on developing lupin species and varieties that not only produce sweet and water-permeable seeds, but also have non-shattering pods to facilitate higher yields with mechanical harvest.

Shedding (or pod drop) or shattering of mature grain, plant lodging and poor plant flow into machinery have been issues for lupin crop harvesting across Australia.

Experience in the southern region indicates it is advisable to harvest lupin as soon as the crop is ripe, as delays can result in significant yield loss from these problems. Grain quality can also be affected.

The best harvesting window is typically within three weeks of crop maturity and when grain moisture content reaches 14 percent. In some seasons, this will be when plant stems are still pale green.

Lupin grain losses can be substantially reduced by harvesting when humidity is high and temperatures are not too hot.

In cooler environments, daytime temperatures are often not warm enough to cause major problems and it may be better to harvest the crop as quickly as possible, rather than switching between lupins and cereals.

Delaying harvest can lead to brittle grain that is susceptible to cracking and splitting – or incidence of staining, lodging, moulds or disease.

It is advised to take care when harvesting lupin grain to use as seed for the next year's crop. Grain harvested late for seed can be of poor quality, with a low percentage of normal seedling germination.

It is recommended to harvest as soon as the crop is mature, setting the harvester drum or rotor speed to a minimum and opening the concave relatively wide.

This tends to reduce damage to the seed embryo and helps facilitate a high germination percentage after sowing. The seed embryo is very sensitive to impact if it becomes dry and brittle.

Even seed with no visible damage may have a low germination percentage if it suffered a high impact at harvest, or during handling post-harvest when moisture content was low.

Harvest is an ideal time to employ weed seed capture and/or destruction to reduce weed burdens and help manage any herbicide resistance issues. See Chapter 5 for more information.

Tactics include creating and burning harvest windrows, towing chaff carts, using the Bale Direct system that bales chaff and straw as it exits the harvester, funneling seeds into tramlines or adopting seed destruction technology.

Storing lupin grain for next year's crop also needs close attention, with harvested grain moisture levels of about 13 percent or less ideal for storage.

Using silo aeration to keep average storage temperatures below 20°C until the next year's sowing is ideal to minimise storage insect pest activity and maintain seed quality.





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GRDC 'Grain Legume Handbook': <u>https://grdc.com.au/</u> grainlegumehandbook

New South Wales Department of Primary Industries 'Windrowing Lupins': <u>http://www.dpi.nsw.gov.au/</u> <u>content/agriculture/broadacre/winter-</u> <u>crops/pulses/lupins/windrowing-</u> <u>lupins</u>

### 10.2 Harvest timing



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**Figure 1:** Lupin is best harvested as soon as the crop is ripe and within three weeks of maturity.

(SOURCE: GRDC)

Risks of plant lodging, pod shattering, pod shedding (or pod drop), grain staining or disease can typically be minimised if lupin is harvested as soon as the crop is ripe and within three weeks of maturity.

In WA trials, yield losses of 5-40 percent have been recorded in some lupin crops due to shattering of grain when harvest is delayed.<sup>1</sup>

A moisture meter is useful to determine when the lupin crop is ready. Harvest is best started when grain moisture content reaches 14 percent.

In some seasons this will occur when plant stems are still pale green, although the seeds will have turned yellow inside the seed coat.

At higher moisture content, the seed may require aeration or drying for longerterm storage.

Harvesting at or below 10 percent moisture can increase the amount of bruised and cracked seed, which reduces quality and may reduce the germination percentage or normal seedling count when it is sown the next year.

A seed can be damaged even though the seed coat may appear undamaged.

Lupin grain losses can be substantially reduced by harvesting when humidity is high (at night or early morning if necessary) and temperatures are not too hot.

In cooler environments, daytime temperatures often do not become warm enough to cause major problems for harvesting.

When harvesting lupin seed for planting the following year, it is advised to carry out harvest:

- » As soon as the crop is mature
- » In cooler, rather than hotter conditions
- » With the harvester drum or rotor speed set to a minimum
- » With the concave opened quite wide.

(SOURCE: DPIRD)



<sup>1</sup> Reithmuller (2008) Successful lupin harvesting in Western Australia – A review. Lupins. Org conference paper.



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### i MORE INFORMATION

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NSW Department of Primary Industries 'Windrowing Lupins': http://www.dpi.nsw.gov.au/\_\_data/ assets/pdf\_file/0007/157237/pulsepoint-10.pdf



### 10.3 Minimising shattering and pod drop

Shattering or dropping of lupin pods on entry to the harvester can lead to significant grain losses in lupin crops as a result of:

- » Vibration due to cutter bar action
- » Plant on plant contact
- Reel on crop impact
- » Poor removal of cut material by the auger.

Risks of shattering or pod drop resulting from splitting of mature pods can be reduced by harvesting in high humidity (at night if necessary) and when temperatures are not too hot.

Crop-topping is a tool used by some growers to help minimise pod shattering by advancing harvest timing and evening-up crop ripening.

This needs to be carried out at the correct crop maturity stage and is not recommended for crops where grain is being retained for planting seed.

Research in NSW has found swathing/windrowing lupin can be useful, when opportunities arise, to avoid pod shatter/drop.<sup>2</sup>

This has a positive spin-off in helping to reduce weed seed set in some years, but can lead to crop yield loss if lupin plant maturity is behind weed seed maturity.

NSW researchers advise swathing/windrowing when the top pods (the pods that are last to mature) are past physiological maturity and in the dry-down phase.

At this stage, the lowest (most mature) pods on the primary or main spike will be close to ripe with a moisture content of about 40 percent. Average grain moisture for the whole plant will be about 65 percent and cotyledons will be turning from bright green to yellow (in narrow leafed varieties).

Trials have found it is best not to windrow albus lupin varieties too early, as immature seeds can become shrivelled when dry.<sup>3</sup>

Swathed/windrowed lupin generally mature in a similar time to a standing crop and will be ready to harvest within about 10-30 days (depending on environment).

It is advisable to use a pick-up front to increase harvest speed and reduce grain losses.

Newer narrow leafed lupin varieties PBA Bateman<sup> $\phi$ </sup>, PBA Jurien<sup> $\phi$ </sup>, PBA Barlock<sup> $\phi$ </sup> and PBA Gunyidi<sup> $\phi$ </sup> have been bred for improved harvest shattering resistance (equal to Coromup<sup> $\phi$ </sup> and Tanjil<sup> $\phi$ </sup>).

### 10.4 Maintaining grain quality

Lupin grain quality can be optimised at harvest by matching timing to correct crop maturity and moisture levels.

Using appropriate machinery can also help maintain quality by avoiding cracked grain and/or pod shattering (pod drop).

Grain staining, fungal and disease issues can be managed with correct disease control and fungicide use at the appropriate stage of crop development. There are receival standards in place for lupin in each state that include moisture content, seed purity, seed size and colour and foreign material. Some pests and weed seeds, such as budworm, phomopsis and wild radish, can also impact on lupin deliveries to market. See Chapter 8 for more detail.



factsheets

**MORE INFORMATION** 

GRDC 'Fact Sheet Retaining Seed':

https://grdc.com.au/resources-

and-publications/all-publications/

<sup>2</sup> New South Wales Department of Primary Industries 'Windrowing lupins': <u>http://www.dpi.nsw.gov.au/content/agriculture/broadacre/</u> winter-crops/pulses/lupins/windrowing-lupins

<sup>3</sup> New South Wales Department of Primary Industries 'Windrowing lupins': <u>http://www.dpi.nsw.gov.au/content/agriculture/broadacre/</u> winter-crops/pulses/lupins/windrowing-lupins



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Seed coat and cotyledon of lupin grain can be discoloured by crop-topping or premature desiccation in parts of paddocks if ripening is uneven.

To maintain quality of lupin grain being stored for subsequent planting, it is advised to harvest at a seed moisture level of 14 percent.

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Research has found it is best to store this grain at an average temperature of about 20°C. There can be significant loss of grain quality when storage temperatures are above 30°C.

A wet harvest can lead to issues of staining and weather damage that reduce lupin grain quality for sale or subsequent planting.

Rain at harvest can also result in lupin seed that produces low seedling vigour at the next planting. It is advisable to harvest seed crops early and before any rain, if possible, to minimise the risk of seed quality issues.

Weather damaged seed grain is more susceptible to poor germination, low vigour and degradation during storage and handling.

Symptoms include loose and wrinkled seed coat, staining or fully germinated seed.

### **10.5 Machinery configuration**

To minimise losses from pods shattering or dropping on entry to the harvester and to avoid damaging lupin grain, recommendations include:

- Reducing the peripheral speed of the harvester drum or rotor to a maximum 12 metres per second (down from 20 to 30 m/s for cereal harvest)
- » Using double density knife guards
- » Extending knife to auger distance
- » Using draper fronts and air reels.<sup>4</sup>

Harvesters will have a range of drum or rotor diameters, each with different speeds.

It is recommended to check the configuration so that the correct rotational speed can be used for lupin crops.

Other general rules of thumb for lupin harvester settings include incorporating:

- » Slow reel speeds
- » High spiral clearance
- » Thresher speeds of 400-600 rpm
- » Concave clearance of 10-30 mm
- » High fan speed
- » Top sieve of 32 mm
- Bottom sieve of 16 mm.

#### Using closed (comb) fronts

Most losses from closed fronts are typically caused by the plant impacting with the spiral.

To avoid the risk of this, it is advisable to ensure the height between the point of cut on the stem and the top of the crop is less than the distance between the knife and centre point of the spiral. Extended fronts – where the gap between the knife and the auger (spiral) has been extended – are recommended.

Losses may also be reduced by increasing the finger gap to 16 mm. Remove a finger as necessary.

When re-adjusting the front for wheat or barley crop harvesting, it is best to check the knife is timed so it stops behind a finger.



<sup>4</sup> Reithmuller (2008) Successful lupin harvesting in Western Australia – A review. Lupins. Org conference paper.



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### Using open fronts

Open fronts have typically replaced closed fronts in rotational cropping operations to increase harvesting flexibility for a wide range of crops.

These fronts are needed for harvesting heavy, dense lupin crops and there are typically two types: conventional auger/tin fronts; and the more recent draper/ belt fronts.

To reduce lupin grain losses and optimise grain quality when using conventional auger or tin fronts, recommendations include:

- » Fitting double density (quad) knife guards
- » Avoiding a double density knife with double density knife guards
- » Using a finger or tyne reel
- » Extending the table and knife forward by up to 300 mm
- » Fitting Lupin Breakers® on the table auger
- » Using a large capacity auger that has 1.5 pitches per rotation
- » Fitting a reduced diameter auger barrel with larger flights than the conventional auger barrel
- » Raising the auger to give a bigger gap between the table and the auger flighting
- » Altering the retractable finger timing when fully retracted at the 2 o'clock position (viewed from driver's left-hand end)
- » Replacing standard reels with air reels (on light crops) either a manifold or full-width fan work well, depending on power available
- » Use a Vibra-Mat® that oscillates with the knife.





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GRDC 'Reducing harvester fire risk: The Back Pocket Guide': <u>https://grdc.</u> <u>com.au/resources-and-publications/</u> <u>all-publications/publications/2013/09/</u> <u>grdc-bpg-reducingharvesterfirerisk</u>

South Australian Grain Harvesting Code of Conduct and Grassland Fire Danger Index: <u>https://www.cfs.</u> <u>sa.gov.au/site/prepare\_for\_a\_fire/</u> <u>prepare\_your\_home\_and\_property/</u> <u>farm\_fire\_safety.jsp</u>

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### 10.6 Managing harvest fire risks

Harvesters are prone to catching fire, but risks can be reduced and crop and machinery losses minimised with good hygiene, inspection and maintenance.

It is estimated that, on average, about 7 percent of harvesters will start a fire in any given year in Australia.  $^{\rm 5}$ 

Pulses – particularly lentil, but including lupin – have the highest susceptibility to starting harvester fires. There was an increased incidence of fire events in pulse crops in parts of the southern region during the 2016-17 harvest.

This was due to higher crop biomass levels after a wetter than average growing season – creating more fire fuel load – and an increase in pulse plantings in many low rainfall areas.

The ignition temperature, which is the temperature at which a fire will start, varies between crops and from year to year. Researchers are continuing to explore the key drivers of ignition temperature across a range of crops and seasonal conditions. This means it is not always possible to predict in advance whether a certain crop is more susceptible to ignition.<sup>6</sup>

Guidelines for reducing harvest fire risk include:

- Be aware of and observe all relevant regulations and policies relating to harvest operations and fire including harvest bans
- Observe the Grassland Fire Danger Index (GFDI) protocol on high fire risk days
- Recognise the main factors that contribute to fires relative humidity, ambient temperature, wind, crop type and conditions
- Focus on harvester service, maintenance and hygiene especially on days
  more hazardous for fire
- Avoid accumulation of flammable material on the manifold, turbocharger and exhaust system of the harvester
- Be aware of side and tail winds that can disrupt the radiator fan air blast that typically keep the exhaust area clean
- Be alert to areas where chaff can build-up such as fuel lines, battery cables, wiring looms, tyres and drive belts
- Avoid overloading electrical circuits
- Periodically check bearings around the harvester front and the machine generally
- Maintain fire extinguishers on the harvester and consider adding a water-type extinguisher for residue fires
- Consider machine-mounted fire suppression systems
- If fitted, use the battery isolation switch when the harvester is parked
- Maintain two-way or mobile phone contact with base and others and establish a plan with the harvest team to respond to fires if one occurs.<sup>7</sup>



<sup>6</sup> GRDC (2013), Reducing Harvester Fire Risk: The Back Pocket Guide, <u>www.grdc.com.au/GRDC-BPG-ReducingHarvesterFireRisk</u>

7 GRDC (2013), Reducing Harvester Fire Risk: The Back Pocket Guide, <u>www.grdc.com.au/GRDC-BPG-ReducingHarvesterFireRisk</u>





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GRDC 'Grain Legume Handbook – Chapter 9': <u>https://grdc.com.au/</u> <u>grainlegumehandbook</u>

Soil Quality.org.au 'Fact Sheet – Benefits of Retaining Stubble – WA': http://www.soilquality.org.au/ factsheets/benefits-of-retainingstubble

### 10.7 Stubble management



**Figure 2:** Stubble retention, such as at this site in western NSW, maintains ground cover, reduces erosion risks and helps conserve valuable soil moisture and nutrients.

(SOURCE: GRDC)

Historically in southern Australia, the practice of removing crop stubbles by burning was widespread for ease of sowing the following year and to break cereal disease cycles.

In recent years, there has been a shift to alternative stubble management tactics, including mulching, slashing or leaving residue partially or wholly standing.

The primary agronomic purposes of stubble retention are to reduce runoff and soil loss from wind or water erosion, conserve soil moisture and nutrients for subsequent crops, protect young seedlings and lower the risks of rain splash of Brown leaf spot spores.

Retaining or partially retaining standing lupin stubble at a level of about two tonnes per hectare typically provides about 50 percent ground cover and research indicates this can significantly reduce soil losses compared to areas where stubbles have been burned.<sup>8</sup>

Stubble from lupin crops will also provide slow release nitrogen (N) to the soil and has an added advantage of commonly containing about 150-250 kilograms of grain per hectare after harvest.

This makes lupin stubbles an excellent grazing source for sheep and cattle during the summer months.



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<sup>8</sup> Soil Quality.org.au 'Fact Sheets – Benefits of Retaining Stubble – WA: <u>http://www.soilquality.org.au/factsheets/benefits-of-retaining-stubble</u>



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If putting stock into stubble, it is recommended to do so shortly after harvest as this can help to avoid stem rot and fungus spread from rain.

Levels of fallen grain in lupin crop residue can often provide enough feed for one to three months of sheep grazing, depending on: stocking rate; any development of lupinosis in livestock; risk of wind erosion; and rainfall.

Lupinosis is a disease that affects livestock that eat dead lupin stems colonised by the fungus *Diaporthe toxica* (formerly known as *Phomopsis leptostromiformis*).

The fungus produces toxins, called *phomopsins*, in warm and moist conditions and when consumed by livestock these can damage the liver and can result in the animal becoming jaundiced.

Typically, lupin stubbles can be burned in autumn if required before sowing the next crop and this is most effective if a complete burn of the paddock is achieved.

### 10.8 Grain storage



**Figure 3:** Quality control is the key focus of on-farm storage for lupin grain to be used for seed the following year.

(SOURCE: GRDC)

Lupin grain with high germination and vigour test results can remain viable in storage for up to three years if seed moisture levels are maintained below 13 percent.

It is advised that storage life will depend on storage temperature and incidence of stored grain pests and diseases.

It is recommended to dry lupin seed at a moisture content above 14 percent before it is stored (especially in unaerated silos).

It is not advisable to delay harvest to achieve these levels of moisture as this can sometimes result in substantial yield and quality losses.

The optimal storage temperature for lupin grain is an average of 20°C and below 25°C.

It is advisable to not store lupin seed contaminated with green pods from wild radish weeds. High temperatures can volatilise toxic compounds from the radish pod that can kill the lupin seed. This process can happen in a matter of days, so temporary storage can be damaging.

### i) MORE INFORMATION

GRDC 'Stored Grain': www.storedgrain.com.au

GRDC 'Back Pocket Guide – Stored Grain Pests Identification': http://storedgrain.com.au/storedgrain-pests-identification-the-backpocket-guide-2011/





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Other tips for optimal storage of lupin grain include:

- » Using white/light silos to reflect heat
- » Using silos with capacity greater than 75 tonnes that remain cooler than smaller silos

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- » Monitoring stored grain pest activity
- » Monitoring grain quality and temperature
- Adopting precautions for any phosphine gas fumigations (only use in sealed storage)
- » Consider aeration cooling systems for stored grain insect and pest control and maintaining grain quality.

Loading and out-loading of lupin grain from storage should be done with care.

Silos are designed to withstand uniform downward and outward forces and to keep these forces uniform, silos must only be loaded from the central top hatch.

Loading from the side top hatch will unbalance the lateral forces on opposite sides of the silo, which could distort the shell of the silo and place extreme pressure on the side holding the high side of the stack.

It is advised that the same principles apply when out-loading and the silo should only be emptied from the bottom central opening.

It is best to not use the 'bagging-off' chute unless the silo is designed to withstand off-centre loads.

The physical characteristics of lupin grains means higher pressures are exerted on silo walls than with some other grains.

When transferred to the lower sections of the silo wall, these forces may cause crimping or pleating of the walls (seen in elevated and flat bottom silos). For this reason, it is advised not to store lupin grain in older type silos with thin walls.





### i) MORE INFORMATION

Pulse Australia 'Pulse Traders': http://pulseaus.com.au/marketing/ pulse-traders

Pulse Australia 'Australian Crop Forecast': <u>http://www.pulseaus.</u> <u>com.au/storage/app/media/</u> <u>industry/20160613\_AU-pulse-crop-</u> <u>forecast.pdf</u>

Pulse Australia 'Australian Pulse Bulletin': <u>http://pulseaus.com.</u> <u>au/growing-pulses/publications/</u> <u>marketing-pulses</u>

# **Grain markets**

### 11.1 Overview

It is estimated lupin grain production in South Australia, Victoria and New South Wales reached a total of about 210,300 tonnes in 2016.

This was made up of an estimated 89,000 t produced from an area of 69,500 hectares in SA; 44,900 t from 33,000 ha in VIC; and 76,400 t from 32,700 ha in NSW.<sup>1</sup>

The bulk of annual narrow leafed lupin grain production in the southern region is used on-farm for animal feed or planting seed, or is sold on the domestic market. Most albus lupin is sold for human consumption.

Manufactured and grain-based ruminant (cow and sheep) feed is the biggest end-use for narrow leafed lupin produced in SA, VIC and NSW, followed by feed for pigs and poultry and a small – but increasing – interest from the aquaculture sector.

Australian exports of narrow leafed lupin grain predominantly occur out of the western region.

The Republic of South Korea is the biggest international buyer of Australian narrow leafed lupin and there are smaller export markets in European Union countries and Japan.

Most of these markets use lupin grain for animal feed, although in recent years there has been interest in its use (processed to flour or flakes) for human consumption.

This is because the grain is uniquely high in protein (30-40 percent) and dietary fibre (30 percent) and low in starch, meaning it has a low glycaemic index (Gl).

Lupin flour and/or flakes are included in a range of bakery, meat and beverage products in Australia, Europe and some other countries – but these remain mostly niche markets.

In 2014-15, Australia exported about 250,000 t of lupin grain (from November 2014 to October 2015) from total national production of 565,000 t in 2014. This included about 75,000 t in SA, 66,000 t in NSW and 40,000 t in Victoria. These export sales were well down from the decade's peak annual lupin grain exports of about 650,000 t in 2011-12, when national production was about 901,000 t.<sup>2</sup>

Lupin grain generally competes with soybean in the international market for vegetable-based proteins for livestock industries.

Australian lupin has consistently been valued at 70–75 percent of the price of soybean meal in global markets.

Since 2007-08, export prices for lupin grain have fluctuated from about \$225 per tonne in 2011-12 to about \$350/t in 2014-15. This has correlated with high and low Australian production levels, respectively.<sup>3</sup>

The price of imported vegetable protein, such as soybean meal, canola meal or palm kernel meal, strongly influences the lupin export price.



<sup>1</sup> Pulse Australia Australian Pulse Crop Forecast (June, 2016): <u>http://www.pulseaus.com.au/storage/app/media/industry/20160613\_AU-pulse-crop-forecast.pdf</u>

<sup>2</sup> Pulse Australia Australian Pulse Crop Forecast (June, 2016): <u>http://www.pulseaus.com.au/storage/app/media/industry/20160613\_AU-pulse-crop-forecast.pdf</u>

<sup>3</sup> Pulse Australia Australian Pulse Crop Forecast (June, 2016): <u>http://www.pulseaus.com.au/storage/app/media/industry/20160613\_AU-pulse-crop-forecast.pdf</u>



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Soybean meal is usually in high supply and can be sourced year-round, enabling forward ordering and regular shipments.

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Monthly average prices for narrow leafed lupin on the domestic market in SA since 2011 have fluctuated from a low of about \$150/t in early 2012 (Port Lincoln Free-in-store) to a high of just over \$350/t in mid-2013 and early 2015. In Melbourne, monthly average prices for narrow leafed lupin have ranged from a low of \$250/t in late 2011 to a high of about \$475/t in mid-2013 and mid-2014.<sup>4</sup>

### **11.2 Export destinations**

In recent years, the Republic of South Korea has been the major international buyer of Australian narrow leafed lupin grain. This market has a high-capacity dehulling plant and uses the hulls in animal feed and kernels for pig feed rations.

Other export markets for Australian narrow leafed lupin include the Netherlands, Egypt, Japan and Spain.

Most use the grain for animal feed, although small human food markets are developing for lupin flour and flakes.

The main export market for albus lupin is Egypt, where the grain is consumed as a snack food.

This is a limited market, which has had a total import requirement of about 50,000 t annually in recent years.

Over-production of albus lupin in Australia can exceed Egyptian market requirements and flatten demand accordingly.

Despite similar nutritive value, albus lupin is not as readily accepted into domestic feed markets as Australian narrow leafed lupin.

This is possibly driven by the historically higher price for this grain in export markets, where demand often out-strips production.

### 11.3 Domestic markets

If growing lupin for sale on the domestic market, it is advised that marketing decisions should factor in Australian seasonal conditions, as these strongly influence farm gate prices.

Drought years tend to increase domestic demand for lupin, which can push prices above those achieved in export markets.

Pulse Australia maintains a list of pulse traders who deal in export and domestic markets. Smaller buyers and traders can be found in local networks.

Pulse Australia recommends growers consider the following factors when making lupin marketing decisions:

- » Estimates of domestic lupin production
- » Estimates of domestic availability, type and quality of protein feeds (including green pasture)
  - On-farm storage capacity to enable marketing across the year
- » World price and availability of soybean meal
- » Demand for on-farm use by graziers as a fodder grain (especially in droughts).

(More information about grain marketing is contained in Chapter 13.)



Pulse Australia 'Pulse Traders': http://pulseaus.com.au/marketing/ pulse-traders



<sup>4</sup> Pulse Australia Australian Pulse Crop Forecast (June, 2016): <u>http://www.pulseaus.com.au/storage/app/media/industry/20160613\_AU-pulse-crop-forecast.pdf</u>



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### MORE INFORMATION

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Lupin Foods Australia: http://www.lupinfoods.com.au/

DPIRD 'Lupin Markets': <u>https://www.</u> agric.wa.gov.au/grains-researchdevelopment/western-australianlupin-industry

### ) MORE INFORMATION

EziGrain 'Lupins Receival Standards for 2016-17': <u>http://ezigrain.abb.com.</u> <u>au/receivalstandards/charts1617/</u> <u>Original%20Lupins%20Receival%20</u> <u>Standards%202016%202017%20</u> <u>1288%20R1.pdf</u>

Pulse Australia 'Australian Pulse Standards 2016-17': <u>http://pulseaus.</u> <u>com.au/storage/app/media/</u> <u>markets/20160801\_Pulse-Standards.</u> <u>pdf</u>



Lupin grain has a unique combination of high protein, high fibre, low oil and virtually no starch.

Less than 4 percent of global lupin production is consumed as human food, but It is estimated about 500,000 t of food containing lupin ingredients is consumed each year in the European Union alone.<sup>5</sup>

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This is mainly through inclusion of low rates of lupin flour in wheat-based bakery products.

Research has found that consuming foods enriched with flour or flakes from Australian narrow leafed lupin can provide a feeling of fullness, resulting in people eating less and consuming fewer kilojoules.<sup>6</sup>

Other potential health benefits of eating lupin include a more balanced blood glucose level, lower cholesterol and improved bowel health.

Lupin-enriched foods have the potential to provide additional health benefits, including:

- » Better satiety (appetite suppression) and energy balance
- » Glycemic control reduced blood glucose and insulin response
- » Improved blood lipids
- » Provision of soluble fibre
- » Lowering of total cholesterol
- » No adverse effect on high-density lipoprotein (HDL) cholesterol.<sup>7</sup>

Several Australian companies process lupin grain to flour and flakes for human food consumption.

It is advised that any expansion of domestic processing capacity could boost the potential for Australian lupin to be used in the large Indonesian tempeh market (in place of soybeans).

This could help to increase lupin prices and stimulate increased production of this grain legume across southern Australia.

### 11.5 Grain specifications

Pulse Australia, in consultation with the Australian pulse industry, compiles standards for all pulse grains to ensure the best quality is provided to customers on world markets.

Some export markets may have additional specific standards and country quarantine restrictions for weed seeds, disease and contaminant levels. Receival standards in domestic and overseas markets can include (but are not restricted to) limits for defective grain, pod material, phomopsis infection on grain, presence of other diseases or pests, foreign material and/or foreign weed seeds/material.

Compliance with these guidelines is typically the responsibility of individual commodity traders and information is communicated to growers directly.

Prices for lupin have been relatively high in recent years, based on strong domestic demand.

The majority of the eastern states' lupin grain production is sold into the local domestic market and often there have been price advantages from storing lupin on-farm or in a warehouse facility to market after harvest.

- 5 Pulse Australia Australian Pulse Crop Forecast (June, 2016): <u>http://www.pulseaus.com.au/storage/app/media/industry/20160613\_AU-pulse-crop-forecast.pdf</u>
- 6 Regina Belski (2011) A little lupin improves the bread of life. University of Western Australia, <u>http://www.news.uwa.edu.au/201106133641/</u> research/little-lupin-improves-bread-life
- 7 Regina Belski (2011) A little lupin improves the bread of life. University of Western Australia, <u>http://www.news.uwa.edu.au/201106133641/</u> research/little-lupin-improves-bread-life





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The Pulse Australia 'Australian Pulse Standards 2016-17' publication lists a range of domestic and export market receival standards and defect classifications for lupin grain.

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These standards cover aspects such as seed purity, moisture, mould, colour, foreign material and snails and apply to all species of lupins (and other pulses), unless specified.

Details can be found at these links: <u>http://pulseaus.com.au/storage/app/</u> <u>media/markets/20160801\_Pulse-Standards.pdf</u> or <u>http://ezigrain.abb.com.au/</u> <u>receivalstandards/charts1617/Original%20Lupins%20Receival%20Standards%20</u> <u>2016%202017%201288%20R1.pdf</u>

These examples of PA receival (delivery) standards for narrow leafed *Angustifolius* lupin are shown in Table 1 and Table 2.

 Table 1: Lupin – Angustifolius minimum receival standards farmer dressed.

Parameter	Requirements	Comments / Variations
Physical Characteristics	The <i>Angustifolius</i> lupin and mature.	shall be of the current season and be dry
Purity	97% Min by weight	Whole <i>Angustifolius</i> lupin, defective <i>Angustifolius</i> lupin and seed coats.
Moisture	14% Max	
Defective	7% Max by weight including Max 36 per 200g Poor Colour seeds, Max 2 per 200g Bitter Dark Seeded lupin, 17 Max per 200g of Phomopsis Affected seeds	Angustifolius lupin not of the specified type. Angustifolius lupin that are broken, chipped, diseased, frost damaged, insect damaged, sappy, shrivelled, split, sprouted, weather damaged, wrinkled. Includes pods that contain Angustifolius lupin, whether broken or unbroken, loose seed coats, poor colour, bitter dark seeded lupin and Phomopsis affected.
Mould	1 grain Max per 200g	Mould (Field and / or Storage), Caked, Bin Burnt & Heat Damaged.
Poor Colour	Max 36 seeds per 200g	Yellow reddish / tan coloured lupin as per the GTA Visual Recognition Standards Guide.
Foreign Material	3% Max by weight, includes 2% Max by weight wild radish and 0.5% Max by weight Unmillable Material	Unmillable material and all vegetable matter other than <i>Angustifolius</i> lupin seed material. Includes tolerance for wild radish.
Unmillable Material	0.5% Max by weight (of which 0.3% Max by weight of soil)	Soil, stones and non-vegetable matter. Please read important note re soil contamination – see Point 14 of Procedures.
Snails	One (1) Max	Dead or alive. Whole or substantially whole (more than half) including bodies per 200g sample.
Field Insects	Fifteen (15) Max	Dead or alive per 200g sample.
Grasshoppers & Locusts	Two (2) Max	Dead or alive per 200g sample.
Foreign Seeds		
Objectionable Material	Nil tolerance	Includes Objectionable Odour.
Ryegrass Ergot	Two (2) cms Max	Pieces laid end to end per 200g sample.

(SOURCE: Pulse Australia, 2016, http://pulseaus.com.au/storage/app/media/markets/20160801\_Pulse-Standards.pdf)





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 Table 2: Lupin – Angustifolius minimum receival standards farmer dressed.

Receival standards							
Narrow leafed, farmer dressed lupin							
Maximum moisture content	Minimum purity	Maximum defective#	Screen size for defective	Poor colour maximum	Foreign material maximum in total		
14%	97%	7%	-	-	3%		
Unmillable material maximum	Snails maximum	Nominated seeds maximum (Type 1)	Nominated seeds maximum (Type 2)	Nominated seeds maximum (Type 3)			
0.5%	1 per 200g	Nil per 200g	5 per 200g	5 per 200g			

(SOURCE: W. Hawthorne)

In addition to the specifications covered by the Australian Pulse Standards, due to Victoria remaining anthracnose free, lupin grain entering Victoria from SA must either:

- » Have Primary Industries and Regions SA (PIRSA) documentation proving it is free of anthracnose
- » Be marketed to specific NSW Department of Primary Industries (NSWDPI) approved end-users
- » Be transported by accredited agencies under strict protocols and specific transport routes.

# **11.5.1** On-farm factors influencing lupin deliveries and marketing

There are a range of agronomic, pest and disease factors that can influence lupin delivery options, marketing strategies and returns to growers.

These include, but are not restricted to, Native budworm (*Helicoverpa punctigera*), Lucerne seed web moth (*Etiella*), snails, Phomopsis stem blight (*Phomopsis leptostromiformis*) and Phomopsis pod blight (*Diaporthe toxica*), weed seed contamination and harvester settings (leading to cracked grain).

#### Pests

#### Native budworm (Helicoverpa punctigera)

This pest can affect returns at harvest from direct lupin grain weight loss (due to seeds being wholly or partly eaten) or downgraded grain quality. Native budworm can cause unacceptable levels of chewed grain or fungal infections introduced via caterpillar entry into seed pods, especially in albus lupin crops (and other pulses with big grains). The percentage of broken, chewed and defective seed found in grain samples affects the final price of pulse crops, particularly those marketed for human consumption.<sup>8</sup>

#### Lucerne seed web moth (Etiella)

Incidence and abundance of Lucerne seed web moth varies by season and location. Severe infestations can result in a loss of lupin yield and quality at harvest. Moth flights commonly occur in mid to late September and often coincide with early pod development in pulse crops. Larvae burrow into pods within 24 hours of hatching and feed on the pods and seeds, remaining until the entire content has been eaten. Adjacent pods may be webbed together as larvae move between pods. Seeds are typically only partially eaten, often with characteristic pin-hole damage. Damage is difficult to grade out and the resulting unattractive appearance reduces seed quality.<sup>9</sup>



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<sup>8</sup> DPIRD (2017) Management and economic thresholds for native budworm, <u>https://www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm?page=0%2C1#smartpaging\_toc\_p1\_s2\_h2</u>

GRDC-Queensland Government, IPM Guidelines for Grains, http://ipmguidelinesforgrains.com.au/wp-content/uploads/Etiella.pdf



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#### Snails

Snails can not only clog up and damage harvesting machinery, causing delays, but also have potential to contaminate grain. In the 'Farmer Dressed' and 'Export Farmer Dressed' markets, the receival standard is a maximum of one snail per 200 g sample. In the 'Export Machine Dressed' standards, there is a nil tolerance of snails.<sup>10</sup>

#### Disease

### Phomopsis stem blight (*Phomopsis leptostromiformis*) and phomopsis pod blight (*Diaporthe toxica*)

This fungal disease can infect all parts of the lupin plant, but is more commonly seen on dry stems at maturity, pods and (in some cases) seed. The fungus produces a toxin that can cause lupinosis in grazing livestock, but also has potential to downgrade grain in the market. On pods, large, irregular reddish-tan lesions appear, often covered with powdery grey mould. Infected seeds either appear normal or are discoloured light yellow to reddish-tan. Web-like grey mould may be seen on the seed coat and inside the seed pod. Small black fungal spots on lupin trash may give the stems a flecked appearance.<sup>11</sup>

#### Weed seed contamination

Weed seed tolerances in delivered lupin grain vary between States and Territories under respective legislation. All persons trading pulses are advised to refer to relevant legislation for appropriate Weed Seed Standards to ensure compliance. There is no tolerance of toxic and/or noxious weed seeds that are prohibited by State laws against inclusion in stockfeed. There are standards for small foreign seeds, which are those that are not the pulse being sampled.<sup>12</sup>

#### Harvester settings

As outlined in Chapter 10, lupin crops should be harvested as soon as they are ripe. If lupin is not harvested within three weeks of maturity, shedding may cause significant yield losses. Losses of 5-40 percent can occur as pods shatter entering the header. Vibration due to cutter bar action, plant on plant, reel on crop impact and poor removal of cut material by the auger all cause shattering and grain loss. Grain loss can be reduced by harvesting in high humidity, at night if necessary, to minimise pod shattering. Avoid reaping in extreme heat. Finger reels are less aggressive than bat reels and cause fewer pod losses. Double acting cutter bars reduce cutter bar vibration losses. Four finger guards with open second fingers also reduce vibrations.<sup>13</sup>



<sup>10</sup> Pulse Australia, (1 August 2016) Australian Pulse Standards 2016/17, Lupins, Angustifolius minimum receival standards farmer dressed parameter requirements, <u>http://pulseaus.com.au/storage/app/media/markets/20160801\_Pulse-Standards.pdf</u>

<sup>11</sup> GRDC Grains Legume Handbook, 2008, <u>https://qrdc.com.au/resources-and-publications/all-publications/publications/2008/03/2008-grains-legume-handbook</u>

<sup>12</sup> Pulse Australia, (1 August 2016) Australian Pulse Standards 2016/17, Lupins, Angustifolius minimum receival standards farmer dressed parameter requirements, <u>http://pulseaus.com.au/storage/app/media/markets/20160801, Pulse-Standards.pdf</u>

<sup>13</sup> GRDC Grains Legume Handbook, 2008, <u>https://grdc.com.au/resources-and-publications/all-publications/publications/2008/03/2008-grains-legume-handbook</u>


# i) MORE INFORMATION

GRDC 'Grain Legume Handbook – Pulses as Stockfeed': <u>https://grdc.</u> <u>com.au/uploads/documents/10%20</u> <u>Pulses%20as%20Stockfeed.pdf</u>

DPIRD 'Lupinosis in Sheep': <u>https://</u> www.agric.wa.gov.au/livestockbiosecurity/lupinosis-sheep

# Lupin as a feed source

# 12.1 Overview

Lupin grain and stubbles can be valuable sources of livestock feed.

The lupin grain is high in crude protein (at 28-34 percent), digestible protein (at 13-15 percent) and metabolisable energy (ME), with low starch levels.

It is a particularly safe feed option for ruminants (cows and sheep), which makes it a desirable and cost-effective stock feed option compared to other pulses and cereals.

The bulk of narrow leafed lupin grain production in the southern region and in Western Australia is used by stockfeed manufacturers and on-farm for animal feed.

The biggest market is feed for ruminants, followed by the pig and poultry sectors.

There is a small, but increasing, use of lupin grain for feed in aquaculture industries and interest from the dairy sector (especially in WA).

There is also growing interest in the use of lupin grain for human consumption due to its potential nutritional and health benefits.

Lupin crop stubbles tend to retain high levels of fallen grain after harvest that can sustain livestock for several weeks or months, depending on location and season.

But a cautious approach to grazing lupin stubbles is advised due to the risk of lupinosis in livestock. This disease can damage an animal's liver, cause loss of appetite, poor production and, potentially, death.





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Lupin is widely used as a source of protein and energy in livestock feeds. The grain and kernel composition changes between lupin types, as outlined in Table 1, and these qualities can assist growers when making feed decisions.<sup>1</sup>

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Table 1: Whole versus dehulled attributes for the different lupin species.<sup>2</sup>

Chemical composition of whole lupin seed and kernels*									
Species	Narrow- leafed lupin		Albus lupin		Yellow lupin		Pearl lupin		
	% wholeseed	% kernel	% wholeseed	% kernel	% wholeseed	% kernel	% wholeseed	% kernel	
Seed coat	24	0	18	0	27	0	16	0	
Moisture	9	12	9	11	9	12	8	10	
Protein	32	41	36	44	38	52	43	52	
Fat	6	7	9	11	5	7	15	17	
Ash	2	3	3	4	3	4	3	4	
Lignin	1	1	1	1	1	1	1	1	
Polysaccharides	22	29	17	21	8	11	9	10	
Oligosaccharides	4	6	7	8	9	12	5	6	
Minor components	0.5	1	0.6	1	0.9	1	1	1	
Available energy contents# MJ/kg									
	MJ/ kg	MJ/ kg	MJ/ kg	MJ/ kg	MJ/ kg	MJ/ kg	MJ/ kg	MJ/ kg	
ME cattle	12.0	15.0	11.9	14.0	-				
DE pigs	14.6	18.3	16.9	19.9	16.4				
AME poultry	10.7	13.4	13.2	15.5	11.4				
Protein and sulphur amino acids (g/kg)**									
Cysteine+Cystine	6.2	-	7.4	-	11.5	-	9.6	-	
Methionine	2.0	-	2.4	-	2.7	-	2.8	-	
Total S-aa's	8.4	-	9.8	-	14.2	-	12.4	-	

#DE is digestible energy, ME is metabolisable energy. \* Source: S. Sipsas, Department of Agriculture WA. \*\* Source: S. Sipsas Perth GRDC Update paper Feb 2004 (by Barkolt and Jensen 1989 method).

Hawthorne, W (2006) Pulses nutritional value and their role in the feed industry, Pulse Australia, <u>http://www.feedgrainpartnership.com</u>, au/items/927/Pulses%20Nutritional%20Value%20and%20Their%20Role%20in%20the%20Feed%20Industry.pdf 2



Hawthorne, W (2006) Pulses nutritional value and their role in the feed industry. Pulse Australia, <u>http://www.feedgrainpartnership.com</u>. au/items/927/Pulses%20Nutritional%20Value%20and%20Their%20Role%20in%20the%20Feed%20Industry.pdf



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A high protein content makes lupin grain a valuable and economic feed for ruminant and monogastric (pigs and poultry) production systems.

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The value of this protein is limited by relatively low levels of methionine and lysine in the grain, but this is not a major problem for cows and sheep that ferment it in the ruminant.

In pig and poultry diets, the shortfalls can be made-up from other proteins or synthetic amino acids.

Lupin grain feed supplements for livestock generally result in higher feed intake, liveweight gain and wool growth than comparable supplements using cereal grains.<sup>3</sup>

The demand for alternative protein resources to fishmeal in aquaculture diets has stimulated interest in the potential of lupins in this sector.

Some major international feed companies are now routinely using lupin kernel meal in aquaculture formulations.

Narrow leafed lupin is the most universally grown pulse in southern Australia and the most widely accepted as stock feed.

The price of these varieties typically also makes them the most economical of the stock feed options and ruminants do not need a period of introduction to the grain to avoid acidosis, due to the absence of starch.

Commercial pig producers have successfully used up to 30 percent whole narrow leafed lupin grain in diet formulations.

Poultry diets typically contain less than 10 percent lupin (commonly in kernel form) due to the problem of 'sticky' or 'wet' droppings.

Albus lupin has higher protein and crude fat content than narrow leafed lupin and is well suited to pig and poultry feed.

Digestability is similar, but more research is needed into depressed intake and reduced growth rates in pigs when lupin comprises more than 15 percent of the diet.

# 12.3 Feed mixes

Lupin has significant advantages in stock feed formulations compared to commonlyused soybean meal, including:

- » Concentrated source of both protein and energy
- » Lack of any major anti-nutritional factors (such as trypsin inhibitors)
- » No requirement for heat treatment
- » Ease of handling and storing due to a robust seed coat.

Lupin grain is readily accepted by most livestock and all types of lupin is mostly free of anti-nutritional factors, such as trypsin inhibitors, lectins and saponins.

In monogastric animals, the complex carbohydrate profile of the lupin grain is the main constraint to its use. This influences net energy yield and has been shown to affect the utilisation of other nutrients in the diet.

# 12.3.1 Ruminants (dairy, beef, sheep)

Ruminant animals can readily digest all components of narrow leafed lupin grain, as resident microbial populations provide the enzymes required to degrade the soluble and insoluble complex carbohydrates.

Content of lignin, the compound that can limit fibre digestion, is very low (at less than 1 percent) and the overall digestibility of lupin grain is about 90 percent.



<sup>3</sup> Hawthorne, W (2006) Pulses nutritional value and their role in the feed industry, Pulse Australia, <u>http://www.feedgrainpartnership.com</u>, <u>au/items/927/Pulses%20Nutritional%20Value%20and%20Their%20Role%20in%20the%20Feed%20Industry.pdf</u>



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This high digestibility, combined with moderate oil content, results in an ME value of about 13 megajoules per kilogram, which is higher than in cereal grains.

A big advantage of lupin grain is that ruminants typically do not require an introduction period to avoid the potential problem of acidosis. This is due to its low starch level and relatively high digestible crude fibre content.

Lupin grains are also large, highly palatable and easily broadcast into thick cereal stubble.

In Australia, lupin grain and crop stubbles are mainly used for sheep grazing, effectively supplementing low roughage diets.

Sheep weight and growth responses vary, depending on the quality of the forage on offer.

The typical efficiency of utilisation of lupin grain in sheep feed in many parts of the southern region varies from a liveweight gain of 0.8 grams liveweight per gram of lupin dry matter for low quality roughages (where sheep are losing weight rapidly), to liveweight gains of 0.2-0.3 g liveweight/gram lupin dry matter where roughage quality is adequate to support maintenance or slow growth.

Lupin supplements typically result in higher feed intake, liveweight gain and wool growth in sheep than comparable supplements of cereals.

This is primarily due to the protein contribution of the grain to rumen microbial protein synthesis. Researchers indicate it could also be linked to rumen bypass protein effects, higher ME content and less disturbance to fibre digestion – which often accompanies the fermentation of cereal starch.<sup>4</sup>

Narrow leafed lupin is routinely used as a feed supplement for dairy production in Australia, Europe and Japan.

# 12.3.2 Monogastrics (pigs, poultry)

Variations in lupin grain protein content are an important consideration in feed formulations for monogastrics, as these animals can only tolerate and efficiently use a certain level in supplements.

Based on research and commercial experience, the maximum inclusion levels of narrow leafed lupin grain recommended for pig diets are:

- » Starter weaner (5-25 kilograms liveweight) 10-15 percent
- » Grower diet (25-60 kg liveweight) 20-25 percent
- » Finisher diet (60 kg to slaughter) 30-35 percent
- » Dry sow diet (gestation) 20 percent
- » Lactating sow diet 20 percent.

It is recommended the poultry feed formulation should not exceed more than 10 percent lupin grain.

This is because it can cause issues with wet or sticky droppings and there is no significant feed conversion above this level.



<sup>4</sup> GRDC (2008) Grain Legume Handbook – Pulses as Stockfeed, GRDC, <u>https://grdc.com.au/uploads/documents/10%20Pulses%20</u> as%20Stockfeed.pdf



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DPIRD 'Grazing Stubbles and Dry Pasture': <u>https://www.agric.wa.gov.</u> <u>au/autumn/grazing-stubbles-and-dry-</u> <u>pasture?page=0%2C2</u>

DPIRD 'Lupinosis in Sheep': <u>https://</u> www.agric.wa.gov.au/livestockbiosecurity/lupinosis-sheep



On average, between 50 and 400 kilograms of grain per hectare can remain on the ground after a lupin crop is harvested. Rates of 300-400 kg/ha are common in some areas.

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This lupin grain in stubbles may be enough to sustain one to three months of livestock grazing unless lupinosis becomes an issue.

Typically in the southern region, weaner sheep show rapid weight gain and wool growth in the first few weeks after being introduced to grazing stubbles and then start to lose weight as the grain is used.

This grain intake and rapid growth generally occurs during early grazing, regardless of stocking rate.

However, heavy stocking rates tend to lead to grain being consumed and used faster, making the rapid livestock growth period shorter and leading to weaners potentially starting to lose weight.

Using lupin stubbles can help to achieve weight gains of up to 200 and 500 g/head in lambs and young cattle respectively.  $^{\rm 5}$ 

# 12.4.1 Lupinosis

Lupinosis is a liver disease of livestock, caused by animals eating lupin stalks affected by the fungus *Diaporthe toxica* (formerly known as *Phomopsis leptostromiformis*).

This fungus produces toxins, called phomopsins, in warm and moist conditions and the disease is common in summer and autumn – particularly after summer rains.

In relatively wet summers, the risk of lupinosis increases, as conditions favour fungal growth (even in resistant lupin varieties) that can often spread to seed and pods.

In these conditions, livestock are more likely to consume toxic fungus from lupin stems, pods or seed.

Symptoms of lupinosis in affected stock can appear as chronic liver dysfunction and can also predispose sheep to nutritional muscle disease (myopathy).

Early signs of lupinosis often develop as the fungus colonises the dead lupin stems.

It is advisable to monitor stubbles for amounts of grain remaining on the ground. If there is less than 50 and 100 kg of grain/ha for sheep and cattle respectively, the stock will tend to consume more potentially fungus-infected lupin stubble. Table 2 can be used to help calculate the level of grain in lupin stubbles to manage lupinosis risks.<sup>6</sup>



<sup>5</sup> DPIRD (2016) Grazing stubbles and dry pasture, DAFWA, <u>https://www.agric.wa.gov.au/autumn/grazing-stubbles-and-dry-pasture?page=0%2C2</u>

Cowley, R, Casburn, G (2013) Reducing the Risk of Lupinosis and the Incidence of Phomopsis, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/\_\_\_data/assets/pdf\_file/0010/478243/Reducing-the-risk-of-lupinosis-and-the-incidence-of-phomopsis.pdf



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 Table 2: Method for calculating amount of grain remaining in a field following harvest.<sup>7</sup>

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



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Cowley, R, Casburn, G (2013) Reducing the Risk of Lupinosis and the Incidence of Phomopsis, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/\_\_\_\_\_\_data/assets/pdf\_file/0010/478243/Reducing-the-risk-of-lupinosis-and-the-incidence-of-phomopsis.pdf



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All livestock, including sheep, cattle, goats, horses and pigs, are susceptible to lupinosis.

Sheep are most susceptible and weaners are most commonly affected because these animals tend to eat less lupin grain and more plant stem.

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The liver damage that occurs from lupinosis increases the risks of pregnancy toxaemia in late pregnancy in ewes or cattle.

Stock affected by lupinosis may develop secondary photosensitisation.<sup>8</sup>

Grazing strategies to reduce risk of lupinosis in the southern region include:

- Graze lupin stubbles soon after harvest (delays increase risk of fungus infection)
- » Graze sheep in mobs smaller than 600 head
- » Stock sheep at less than 10 animals/ha
  - Graze stubbles that do not have pycnidia (leopard spotting)
- Graze paddocks sown with clean seed (with a minimum of a four-year gap between lupin crops)
- » Do not graze stubbles that contain discoloured seed. 9,10

Acute signs of lupinosis in livestock include:

- » Marked appetite reduction
- » Jaundice (yellowing of the white of the eyes and other mucous membranes)
- » Lethargic animals isolated animals in a paddock or tail of the mob
- » Dead and moribund animals
- » On post-mortem, jaundice is evident in the tissues and the liver is markedly swollen and yellow.<sup>11</sup>

Chronic signs of lupinosis in affected livestock include:

- » Loss of condition
- » Weak, lethargic animals
- » Animals that cannot keep up with the mob or are on their own
- » Sheep moving with a stiff-legged gait and hunched back
- » Sheep wandering in disorientated manner
- Sheep caught in fences or pressing their head against objects.<sup>12</sup>

Signs that may be seen in both acute and chronic lupinosis in livestock include:

» Abortions

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- » Reduced lambing percentages
- » Lower wool production
- » Lower wool fibre diameter and low staple strength.<sup>13</sup>

Treatment options for lupinosis in livestock include:

- » Immediately removal of stock from affected lupin stubble
- » Place affected stock in a small paddock with shade and water
- » Provide a small amount of oats in the best-quality grassy paddock, or goodquality oaten hay
- » Avoid paddocks with green plants, as stock will be susceptible to photosensitisation
- 8 DPIRD (2016) Lupinosis in sheep, DAFWA, <u>https://www.agric.wa.gov.au/livestock-biosecurity/lupinosis-sheep</u>
- 9 Cowley, R, Casburn, G (2013) Reducing the Risk of Lupinosis and the Incidence of Phomopsis, NSW Department of Primary Industries, <u>http://www.dpi.nsw.gov.au/\_\_\_\_\_data/assets/pdf\_\_file/0010/478243/Reducing-the-risk-of-lupinosis-and-the-incidence-of-phomopsis.pdf</u>
- 10 DPIRD (2016) Lupinosis in sheep, DAFWA, <u>https://www.agric.wa.gov.au/livestock-biosecurity/lupinosis-sheep</u>
  - DPIRD (2016) Lupinosis in sheep, DAFWA, <u>https://www.agric.wa.gov.au/livestock-biosecurity/lupinosis-sheep</u>
- 12 DPIRD (2016) Lupinosis in sheep, DAFWA, https://www.agric.wa.gov.au/livestock-biosecurity/lupinosis-sheep
- 13 DPIRD (2016) Lupinosis in sheep, DAFWA, <u>https://www.aqric.wa.gov.au/livestock-biosecurity/lupinosis-sheep</u>





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» Do not feed lupin or feed blocks (the damaged liver is unable to effectively metabolise a high-protein diet)

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» Reduce all stress, restore appetite and avoid dehydration during the first couple of weeks of the convalescent period.<sup>14</sup>

If animals regain appetite this is a sign that they will typically fully recover within six months.

However, animals that are severely affected and do not start eating within a couple of days may be best treated with euthanasia. $^{15}$ 

Newer narrow leafed lupin varieties have some resistance to the fungus causing lupinosis. Stubbles and grain from these varieties tend to develop low levels of toxicity.

Good paddock management can assist in ensuring stock are not grazing stems and are only seeking fallen grain.

Other tactics to prevent lupinosis occurring in livestock include:

- » Graze early
- » Provide water in varying locations to force stock to travel
- » Pre-feed stock seed to train foraging
- » Check stock conditions for signs of the condition
- » Remove stock once lupin seed count drops
- » Check lupin seed for fungus infection
- » If more than 10 percent of the lupin seed is discoloured (pale yellow to a darker purple brown) do not feed to stock.<sup>16</sup>

16 DPIRD (2016) Lupinosis in sheep, DAFWA, <u>https://www.agric.wa.gov.au/livestock-biosecurity/lupinosis-sheep</u>



<sup>14</sup> DPIRD (2016) Lupinosis in sheep, DAFWA, <u>https://www.agric.wa.gov.au/livestock-biosecurity/lupinosis-sheep</u>

<sup>15</sup> DPIRD (2016) Lupinosis in sheep, DAFWA, <u>https://www.agric.wa.gov.au/livestock-biosecurity/lupinosis-sheep</u>



# i) MORE INFORMATION

Pulse Australia 'Pulses – Understanding Global Markets': <u>http://www.pulseaus.com.au/growing-</u> <u>pulses/publications/marketing-</u> <u>pulses#world-pulse-production-</u> <u>calendar</u>

Pulse Australia 'Pulse Traders': http://www.pulseaus.com.au/ marketing/pulse-traders

Australian Export Grains Innovation Centre 'Australian Grain Note – Pulses': <u>http://www.pulseaus.com.</u> <u>au/storage/app/media/using\_pulses/</u> <u>AGN\_Pulse-Note-LR.pdf</u>

# **Grain Marketing**

# This chapter was produced and supplied by Profarmer Australia.

# 13.1 Overview

The final step in generating farm income is converting the tonnes of grain produced to dollars at the farm gate. This section provides best-in-class marketing guidelines for managing price variability to protect income and cash-flow.

As shown in Figure 1, Port Lincoln Lupin values have varied from \$70 to \$210 per tonne during the past seven years. This is a variability of 30 to 90 percent. For a property producing 200 t of lupins, this means an income difference of \$14,000 to \$42,000, depending on timing of sales.



<sup>400</sup> Source: Profarmer Australia

Figure 1: Intra-season lupin value variations (in dollars per tonne) at Port Lincoln.

# 13.2 Selling Principles

The aim of a selling program is to achieve a profitable average price (the target price) across the entire business. This requires managing several unknowns to establish the target price and then working toward achieving that target price.

Unknown factors include the amount of grain available to sell (production variability), the final cost of that production and the future prices that may result. Australian farm gate prices are subject to volatility caused by a range of global factors that are beyond grower control and difficult to predict.

The skills growers have developed to manage production unknowns can be used to manage pricing unknowns. This guide will help growers manage and overcome price uncertainty.





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## 13.2.1 Be prepared

Being prepared and having a selling plan is essential for managing uncertainty. The steps involved are forming a selling strategy and a plan for effective execution of sales.

A selling strategy consists of when and how to sell:

#### When to sell

This requires an understanding of the farm's internal business factors including:

- » Production risk
- » A target price based on cost of production and a desired profit margin
- » Business cash flow requirements.

#### How to sell

This is more dependent on external market factors including:

- » Time of year determines the pricing method
- » Market access determines where to sell
- » Relative value determines what to sell.

Key selling principles when considering sales during the growing season and production cycle of a crop are outlined in Figure 2.



Figure 2: Grower commodity selling principles timeline.







## 13.2.2 Establish a business risk profile – when to sell

Establishing your business risk profile allows the development of target price ranges for each commodity and provides confidence to sell when the opportunity arises. Typical business circumstances and how to quantify those risks during the production cycle are described in Figure 3.



Figure 3: Typical farm business circumstances and risk.

The decision-making process for when a grower will sell their grain is dependent on:

- » Does production risk allow sales?
- » What portion of production?
- » Is the price profitable?
- » Are business cash requirements being met?

# 13.2.3 Production risk profile of the farm

Production risk is the level of certainty around producing a crop and is influenced by location (climate and soil type), crop type, crop management and time of the year.

The principle is you can't sell what you don't have. Don't increase business risk by over committing production.

Establish a production risk profile by:

- » Collating historical average yields for each crop type and a below average and above average range
- » Assessing the likelihood of achieving average based on recent seasonal conditions and seasonal outlook
- » Revising production outlooks as the season progresses.

The quantity of crop grown is a large unknown early in the year, but not a complete unknown. You can't sell what you don't have, but it is important to compare historical yields to get a true indication of production risk. This risk reduces as the season progresses and yield becomes more certain. Businesses will face varying production risk level at any given point in time with consideration to rainfall, yield potential, soil type, commodity etc.







The typical production risk profile of a farm is illustrated in Figure 4.

Figure 4: Typical production risk profile of a farm operation.

# **13.2.4** Farm costs in their entirety, variable and fixed costs (establishing a target price)

A profitable commodity target price is the cost of production per tonne plus a desired profit margin. It is essential to know the cost of production per tonne for the farm business.

The principle is don't lock in a loss. If you are committing production ahead of harvest, ensure the price is profitable.

Steps to calculate an estimated profitable price based on total cost of production and a range of yield scenarios is provided in the Grains Research and Development Corporation 'Farming the Business' manual. It also provides a cost of production template and tips on grain selling versus grain marketing and can be found at this link <u>http://www.grdc.com.au/FarmingTheBusiness</u>

## 13.2.5 Income requirements

Understanding farm business cash-flow requirements and peak cash debt enables grain sales to be timed so that cash is available when required. This prevents having to sell grain below the target price to satisfy a need for cash.

The principle is don't be a forced seller. Be ahead of cash requirements to avoid selling in unfavourable markets.

A typical cash-flow to grow a crop is illustrated in Figure 5. Costs are incurred upfront and during the growing season with peak working capital debt incurred at or before harvest. This will vary depending on circumstance and enterprise mix.







Figure 5: Typical farm operating cash balance.

The operating cash flow of a typical farm that is assuming a heavy reliance on cash sales at harvest versus a farm business which spreads sales out throughout the year is also clearly shown in Figure 5.

When harvest sales are more heavily relied on, costs are incurred during the season to grow the crop. This results in peak operating debt levels at or near harvest. At harvest, there is often a cash injection required for the business. An effective marketing plan will ensure a grower is 'not a forced seller' in order to generate cash flow.

By spreading sales throughout the year, a grower may not be as reliant on executing sales at harvest time to generate required cash flow for the business. This provides a greater ability to capture pricing opportunities in contrast to executing sales in order to fulfil cash requirements.

# 13.3 Ensuring access to markets

Once the selling strategy of when and how to sell is sorted, planning moves to storage and delivery of commodities to ensure timely access to markets and execution of sales. At some point, growers will need to deliver the commodity to market. Planning where to store the commodity is important in ensuring access to the market that is likely to yield the highest return.

When a grower has made the decision to sell, the question becomes how they achieve this. The decision about storage and when to sell is outlined in Figure 6 and can depend on:

- » The time of year determines the pricing method
- » Market access determines where to sell
- » Relative value determines what to sell.





Figure 6: Effective storage decisions.

Planting

Execution

## 13.3.1 Storage and logistics

Growing period

Return on investment from grain handling and storage expenses is optimised when storage is considered in light of market access to maximise returns as well as harvest logistics.

Prudent contract allocation

Harvest

Effective storage use

Effective execution against contracts

Profarmer

Planting

Gro

Storage alternatives include variations around the bulk grain handling system, private off-farm storage and on-farm storage. Delivery and quality management are key considerations in deciding where to store your commodity.

The principle is harvest is the first priority. Getting the crop in the bin is most critical to business success during harvest and selling should be planned to allow focus on harvest.

Bulk export commodities requiring significant quality management are best suited to the bulk grain handling system. Commodities destined for the domestic end-user market (such as feed lot, processor or container packer), may be more suited to onfarm or private storage to increase delivery flexibility.

Storing commodities on-farm requires prudent quality management to ensure delivery at agreed specifications and can expose the business to high risk if this aspect is not well planned. Penalties for out-of-specification grain on arrival at a buyer's weighbridge can be expensive. The buyer has no obligation to accept delivery of an out-of-specification load. This means the grower may have to incur the cost of taking the load elsewhere and potentially finding a new buyer. There is potential for a distressed sale which can be costly.

On-farm storage also requires prudent delivery management to ensure commodities are received by the buyer on time with appropriate weighbridge and sampling tickets.

The principle is storage is all about market access. Storage decisions depend on quality management and expected markets, as shown in Figure 7.





Figure 7: Grain storage decision making.





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GRDC 'Stored Grain': <u>http://storedgrain.com.au/</u>



# 13.3.2 Cost of carrying grain

Storing grain to access sales opportunities post-harvest invokes a cost to carry grain. Price targets for carried grain need to account for the cost of carry.

Carry costs consist of:

- » Monthly storage fees charged by a commercial provider
- » Capital cost allocation where on-farm storage is used
- » Interest associated with having wealth tied up in grain, rather than cash or against debt.

The price of carried grain needs to be higher than what was offered at harvest. The cost of carry applies to storing grain on-farm, as there is a cost of capital invested in the farm storage plus the interest component

The principle is carrying grain is not free. The cost of carrying grain needs to be accounted for if holding grain and selling it after harvest is part of the selling strategy.

Optimising farm gate returns involves planning the appropriate storage strategy for each commodity to improve market access and covering carry costs in pricing decisions, as highlighted in Figure 8.



Figure 8: Cash values vs cash adjusted for the cost of carry.





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# (i) MORE INFORMATION

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Grain Trade Australia 'A Guide to Taking out Grain Contracts': <u>http://www.australiangrainexport.</u> <u>com.au/docs/Grain%20Contracts%20</u> <u>Guide.pdf</u>

Grain Trade Australia 'Grain Trade Rules, Contracts and Vendor Declarations': <u>http://www.graintrade.</u> org.au/contracts

Grain Trade Australia 'Trading Standards': <u>http://www.graintrade.</u> org.au/commodity\_standards

Profarmer 'Australian Grain Prices, Analysis and Selling Tactics': http://www.profarmergrain.com.au

GrainCorp 'Grain Transact Resource Centre': <u>http://www.graintransact.</u> <u>com.au</u>

Australian GrainFlow Network: http://www.grainflow.com.au

Emerald Grain: <u>http://emeraldgrain.</u> com/grower-logins/

Clear Grain Exchange: <u>https://www.</u> cleargrain.com.au/get-started

Daily Grain: <u>https://www.dailygrain.</u> <u>com.au/</u>

# 13.4 Executing tonnes into cash

This section provides guidelines for converting the selling and storage strategy into cash by effective execution of sales.

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# 13.4.1 Set up the tool box

Selling opportunities can be captured when they arise by assembling the necessary tools in advance. The tool box includes:

#### **Timely information**

This is critical for awareness of selling opportunities and includes:

- » Market information provided by independent parties
- » Effective price discovery including indicative bids, firm bids and trade prices
- » Other market information pertinent to the particular commodity.

#### **Professional services**

Grain selling professional service offerings and cost structures vary considerably. An effective grain selling professional will put their clients' best interest first by not having conflicts of interest and investing time in the relationship. Return on investment for the farm business through improved farm gate prices is obtained by accessing timely information, greater market knowledge and greater market access from the professional service.

This link <u>http://www.graintrade.org.au/membership</u> contains current financial members of Grain Trade Australia (GTA), including buyers, independent information providers, brokers, agents and banks providing over-the-counter grain derivative products (swaps).

# 13.4.2 How to sell for cash

Like any market transaction, a cash grain transaction occurs when a bid by the buyer is matched by an offer from the seller. Cash contracts are made up of the following components, with each component requiring a level of risk management:

#### Price

Future price is largely unpredictable hence devising a selling plan to put current prices into the context of the farm business is critical to manage price risk.

#### **Quantity and Quality**

When entering a cash contract, there is a commitment to delivery of the nominated amount of grain at the quality specified. Hence production and quality risk must be managed.

#### **Delivery terms**

Timing of title transfer from the grower to the buyer is agreed at time of contracting. If this requires delivery direct to end users it relies on prudent execution management to ensure delivery within the contracted period.

#### **Payment terms**

In Australia, the traditional method of contracting requires title of grain to be transferred ahead of payment. This means counter-party risk must be managed.

Typical cash contracting to GTA standards is shown in Figure 9





This Contract has been executed and this form serves as confirmation and should be signed and a copy returned to the buyer/seller immediately. 2014 Edition







The price point in a cash contract will depend on where the transfer of grain title will occur along the supply chain. The terminology used to describe pricing points along the grain supply chain is shown in Figure 10, along with the associated costs to come out of each price before growers receive their net farm gate return.



Figure 10: Costs and pricing points through the supply chain.





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Cash sales generally occur through three methods:

#### Negotiation via personal contact

Traditionally prices are posted as a 'public indicative bid'. The bid is then accepted or negotiated by a grower with the merchant or via an intermediary. This method is the most common and available for all commodities.

#### Accepting a public firm bid

Cash prices in the form of public firm bids are posted during harvest and for warehoused grain by merchants on a site basis. Growers can sell their parcel of grain immediately by accepting the price on offer via an online facility and then transfer the grain online to the buyer. The availability of this depends on location and commodity.

#### Placing a firm offer

Growers can place a firm offer price on a parcel of grain by approaching buyers with a set tonnage and quality at a pre-determined price. The buyers do not have to accept the offer and may simply say no or disregard the offer.

There are increasingly more channels via which to place a firm offer.

One way this can be achieved anonymously is using the Clear Grain Exchange, which is an independent online exchange. If the firm offer and firm bid matches, the parcel transacts via a secure settlement facility where title of grain does not transfer from the grower until funds are received from the buyer. The availability of this depends on location and commodity.

Anonymous firm offers can also be placed to buyers by an intermediary acting on behalf of the grower. If the grain sells, the buyer and seller are disclosed to each counter-party.

Some bulk handler platforms are also providing facilities for sellers to place firm offers to the market, including GrainCorp through its CropConnect product. A grower can also place a firm offer directly with an individual buyer.

# 13.4.3 Counter-party risk

Most sales involve transferring title of grain prior to being paid. The risk of a counterparty defaulting when selling grain is very real and must be managed. Conducting business in a commercial and professional manner minimises this risk.

The principle is seller beware. There is not much point selling for an extra \$5/t if you don't get paid.

Counter-party risk management includes:

- » Dealing only with known and trusted counter-parties
- » Conducting a credit check (banks will do this) before dealing with a buyer you are unsure of
- » Only selling a small amount of grain to unknown counter-parties
- » Considering credit insurance or letter of credit from the buyer
- » Never delivering a second load of grain if payment has not been received for the first.

It is advised to not part with title of grain before payment, or request a cash deposit of part of the value ahead of delivery. Payment terms are negotiable at time of contracting. Alternatively, the Clear Grain Exchange provides secure settlement through which the grower maintains title of grain until payment is received by the buyer. Then title and payment is settled simultaneously.

Above all, act commercially to ensure the time invested in a selling strategy is not wasted by poor counter-party risk management. Achieving \$5/t more and not getting paid is a disastrous outcome.



Grain Traders Australia 'Managing Counter-party Risk 14/7/2014': <u>http://</u> www.graintrade.org.au/sites/default/ files/Grain%20Contracts%20-%20 Counterparty%20Risk.pdf

Clear Grain Exchange 'Title Transfer Model': <u>https://www.cleargrain.com.</u> <u>au/get-started</u>

GrainGrowers 'Guide to Managing Contract Risk': <u>www.graingrowers.</u> <u>com.au/policy/resources</u>

Counter-party Risk: A Producer Perspective, Leo Delahunty <u>http://</u> www.graintrade.org.au/sites/ default/files/GTA\_Presentations/ Counterparty%20risk%20-%20a%20 producer's%20perspective%20-%20 Leo%20Delahunty.pdf





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Grain sales revenue is optimised when selling decisions are made in the context of the whole farming business. The aim is to sell each commodity when it is priced well and to hold commodities that are not well-priced at any given time. That is, give preference to the commodities of the highest relative value. This achieves price protection for overall farm business revenue and enables more flexibility to a grower's selling program, while achieving the business goals of reducing overall risk.

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The principle is sell valued commodities, not undervalued commodities. If one commodity is priced strongly relative to another, focus sales there. Don't sell the cheaper commodity for a discount.

# 13.4.5 Contract allocation

Contract allocation means choosing which contracts to allocate your grain against come delivery time. Different contracts will have different characteristics (such as price, premiums-discounts, oil bonuses etc.) and optimising the allocation reflects immediately on the business bottom line.

Consideration needs to be made based on the quality or grades you have available to deliver, the contracts you already have in place and how revenues will be calculated on each contract. Key considerations include whether the contract calculates revenues based on a sliding scale, or on pre-determined quality 'buckets'. Whenever there is more grain to allocate than pre-committed to contracts, don't forget to consider the premiums and discounts available in the current cash market as part of the contract allocation decision.

The principle is don't leave money on the table. Contract allocation decisions don't take long and can be worth thousands of dollars to your bottom line.

# 13.4.6 Reading market signals

The appetite of buyers to buy a particular commodity will differ over time, depending on market circumstances. Ideally growers should aim to sell their commodity when buyer appetite is strong and stand aside from the market when buyers are not that interested in buying the commodity.

Appetite in pulse markets can be fickle, erratic and the buy-side can be illiquid. Monitoring market signals is critical to achieving the best possible returns.

The principle is sell when there is buyer appetite. When buyers are chasing grain, growers have more market power to demand a price when selling.

Buyer appetite can be monitored by the number of buyers at or near the best bid in a public bid line-up. If there are many buyers, it could indicate buyer appetite is strong. However, if there is one buyer \$5/t above the next best bid, it may mean cash prices are susceptible to falling \$5/t if that buyer satisfies their buying appetite. In pulse markets the spread between the highest and the second highest bidder can be more than \$100/t at times.

Monitoring actual trades against public indicative bids is also important. When trades are occurring above indicative public bids, this may indicate strong appetite from merchants and the ability for growers to offer their grain at price premiums to public bids.

The selling strategy is converted to maximum business revenue by:

- » Ensuring timely access to information, advice and trading facilities
- » Using different cash market mechanisms when appropriate
- » Minimising counter-party risk by effective due diligence
- » Understanding relative value and selling commodities when these are priced well
- » Thoughtful contract allocation
- » Reading market signals to extract value from the market or prevent selling at a discount.







# 13.5 Market dynamics and execution

# 13.5.1 Price determinants for southern lupin

Australia is a relatively small player in terms of world pulse production, producing 1.5-2.5 million tonnes (mt) of pulses in any given year versus global production of approximately 60 mt. Lupins make up only a small part of this global pulse complex, with estimates pointing to only marginally more than 1 mt being produced annually. Australia makes up a considerable proportion of global lupin production. Australian annual production has ranged from 550-650,000 t in recent seasons, accounting for 50-80 percent of global production and positioning it as the key global market participant.

There are two major types of lupins grown in Australia. The narrow leafed lupin (or Australian sweet lupin) is the predominant variety grown, with the bulk of production occurring in WA. Narrow leafed lupin varieties are predominately used for stockfeed and, with a relatively small domestic stockfeed market in WA, the majority of the State's production is exported. Comparatively, the albus lupin is primarily used for human consumption and production – although considerably smaller – is spread throughout New South Wales, Victoria, South Australia and WA. In the southern growing regions, lupins are spread across a wide area of both SA and VIC. Primarily it is the narrow leafed lupin that is produced, with 100-150,000 t produced across the two states each year. Albus lupins are grown in the southern region, but production is only an estimated 1000 to 3000 t each year.

The major export markets for lupins vary depending on variety. The export market for albus lupins is primarily Egypt, where these are used for human consumption in the snackfood industry. With the Egyptian import requirement estimated at just 50,000 t each year, a change in Australian production for this type can result in a notable under or over-supply. Comparatively, the major export markets for the narrow leafed lupin consist of South Korea, the European Union (EU) and Japan. These markets import an average 200-350,000 t of Australian lupins each year to be used as stockfeed. In the southern growing regions, the big majority of the narrow leafed lupin crop is consumed by the local domestic market as ruminant feed. Very little of the crop is bound for export.

With lupins predominately used for stockfeed, these are valued in relation to other competing protein commodities. Australia is typically the sole exporter of lupins into the global market. Rather than competing against other export origins, it competes against substitute protein products. The biggest competitor is the soybean complex. Lupins sold into export markets are typically valued at a price relative to that of soybean meal. Given this dynamic, Australian farm gate prices are heavily influenced by local production volatility and international trade values for substitute protein products such as soybean meal.

Some of the global influences on Australian lupin pricing are:

- The world price and availability of soybean meal (biggest influence on export values)
- » Lupin production in origins outside of Australia.

While Australia is by far and away the biggest producer of lupins globally, if production increases in outside regions it can impact the import requirements for Australian produce in the coming season. This is particularly true in the EU, where increases in production can result in reduced appetite from neighbouring nations and key importers including Spain and the Netherlands. The global lupin production calendar is shown in Figure 11.







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Figure 11: Global lupin production calendar.

Local influences on Australian lupin pricing include:

- » Domestic production of each lupin variety
- » Availability and quality of local protein feeds
- » Seasonal conditions and the subsequent demand for feed grain
- » Price of imported protein meals (such as soybean meal) and local protein meal prices (such as canola meal, soybean meal).

Appetite for feed grains, including protein feed, can vary greatly depending on seasonal conditions. Drought has led to sharp increases in appetite for narrow leafed lupin varieties as graziers and feedlotters are required to increase the volumes of feed they purchase.

Australian lupin exports are typically strongest shortly after our harvest as buyers seek to move crop to fulfil immediate appetite.

The five-year average monthly lupin export pace (in thousand tonnes) is illustrated in Figure 12.



**Figure 12:** Five-year average monthly lupin export pace ('000t) from Australian Crop Forecasters.

# 13.5.2 Ensuring market access for southern lupin

The market for the southern lupin crop varies greatly depending on the variety grown and where it is produced. Narrow leafed lupins, which make up more than 90-95 percent of the lupin production of VIC and SA, are typically absorbed in the local domestic feed complex as stockfeed. On-farm storage allows more flexibility in accessing this market when it is most favourable to the grower and remains popular given the favourable way in which lupins store.





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Once stored on-farm, lupins can be sold and delivered into private storage or directly to an end-user when it is most favourable. Private commercial storage may offer a viable alternative if on-farm storage is not available.

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Albus lupins are ultimately bound for export for human consumption purposes. Egypt remains the main buyer. Production in VIC and SA is not big enough to warrant exporting in bulk vessels, which means the albus lupin market is executed through the container or 'delivered' market. To ensure access to this market, grain is required to be stored on-farm or delivered directly to the 'packer' at the time of harvest.

Albus lupins that do not make the required specifications for export are able to be sold into the domestic feed market, with the same market access principles applied for narrow leafed lupins to be followed. The Australian supply chain flow is shown in Figure 13.



Figure 13: Australian supply chain flow.

Storage decisions should be determined by assessing market access. The majority of eastern and southern Australian lupins are either exported in containers, or consumed domestically. Private commercial storage and on-farm storage can both provide efficiencies to market.

Quarantine restrictions for importation of SA lupin into VIC and NSW were put in place in 1996 due to sporadic occurrence of anthracnose in broadacre lupin crops on the Eyre Peninsula (but this has not been sighted in recent years).

More information about VIC quarantine rules is available at: <u>http://agriculture.vic.gov.</u> <u>au/agriculture/horticulture/moving-plants-and-plant-products/moving-plants-within-victoria/compliance-and-verification-agreements/lupin-anthracnose</u>

Anthracnose was reported in NSW crops in 2016 and eradication zones have been set up. More information is available at: <u>http://www.dpi.nsw.gov.au/biosecurity/plant/</u>recent-pest-arrivals/lupin-anthracnose







# 13.5.3 Executing tonnes into cash for southern lupin

Given the volatile nature of lupin pricing, setting a target price using the principles outlined in this Chapter minimises the risk of taking a non-profitable price or holding out for an unrealistically high price that may not occur. Pricing deciles for lupins are provided as a guide and are illustrated in Figure 14.





Selling options for lupins include:

#### Store on farm then sell

This is the most common occurrence, particularly for narrow leafed lupins. Lupins are safe to store and require less maintenance than cereal grains. It does remain important to monitor quality, particularly for albus varieties, which will be required to meet export specification requirements. There must be consideration of the cost of storage in target pricing.

#### Cash sale at harvest

This is the least preferred option, as buyer demand does not always coincide with harvest. This is particularly true for albus variety lupins where there are limited buyers and an influx of grower selling can pressure values lower.

#### Warehouse then sell

This provides flexibility for sales if on-farm storage is not available. There should be consideration of warehousing costs in cost of production and target prices. The availability to warehouse lupins in the southern region is limited, with the major bulk grain handlers not providing this service due to the low volumes of production in the region. This may not be an option readily available to many growers in the southern region.

There are some forward price mechanisms available for lupins, including traditional fixed volume forward contracts and – less common – area contracts. Area based contracts tend to price at a discount to fixed volume contracts and this discount needs to be weighed-up against the level of production risk inherent in each contract.

As with all sales, counter-party risk and understanding contract of sale is essential. Counter-party risk considerations are especially important for pulse marketing, as there is often a higher risk of contract default in international pulse markets than for canola or cereals. This is due to the markets they are traded into and lack of appropriate price risk tools (such as futures). This can place extra risk on Australian based traders endeavouring to find homes for product. Lupin price history out of Port Lincoln is shown in Figure 15.







Figure 15: Long term Port Lincoln Lupin price history.





# **Current Research**

# Project Summaries https://grdc.com.au/research/projects

As part of a continuous investment cycle each year the Grains Research and Development Corporation (GRDC) invests in several hundred research, development and extension and capacity building projects. To raise awareness of these investments, the GRDC has made available summaries of these projects. These project summaries have been compiled by the GRDC's research partners with the aim of raising awareness of the research activities each project investment. The GRDC's project summaries portfolio is dynamic: presenting information on current projects, projects that have concluded and new projects which have commenced. It is updated on a regular basis. The search function allows project summaries to be searched by keywords, project title, project number, theme or by GRDC region (i.e. northern, southern or western region). Where a project has been completed and a final report has been submitted and approved a link to, a summary of the project's final report appears at the top of the page. The link to Project Summaries is <u>https://grdc.com.au/research/projects</u>

# Final Report Summaries https://grdc.com.au/research/reports

In the interests of raising awareness of the GRDC's investments among growers, advisers and other stakeholders, the GRDC has made available final reports summaries of projects. These reports are written by GRDC research partners and are intended to communicate a useful summary, as well as present findings of the research activities from each project investment. The GRDC's project portfolio is dynamic, with projects concluding on a regular basis. In the final report summaries there is a search function that allows the summaries to be searched by keywords, project title, project number, theme or GRDC regions. The advanced options also enables a report to be searched by recently added, most popular, map or just browse by agro-ecological zones The link to the Final Report Summaries is <u>https://grdc.com.au/research/reports</u>

# Online Farm Trials www.farmtrials.com.au

The Online Farm Trials project brings national grains research data and information directly to the grower, agronomist, researcher and grain industry community through innovative online technology. Online Farm Trials is designed to provide growers with the information they need to improve the productivity and sustainability of their farming enterprises. Using specifically developed research applications, users are able to search the Online Farm Trials database to find a wide range of individual trial reports, project summary reports and other relevant trial research documents produced and supplied by Online Farm Trials contributors. The Online Farm Trials website collaborates closely with grower groups, regional farming networks, research organisations and industry to bring a wide range of crop research datasets and literature into a fully accessible and open online digital repository. Individual trial reports can also be accessed in the trial project information via the Trial Explorer. The link to the Online Farm Trials is 'Online trials' <u>http://www.farmtrials.com.au</u>





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# References

- Agriculture Victoria, Lupin Anthracnose, <u>http://agriculture.vic.gov.au/agriculture/horticulture/</u> <u>moving-plants-and-plant-products/moving-plants-within-victoria/compliance-and-verification-</u> <u>agreements/lupin-anthracnose</u>
- Anderson, G, Brennan, R, Bell, R, Chen, W (2015) Making better fertiliser decisions for cropping systems in Western Australia. Soil test – crop response relationships and critical soil test values and ranges, DAFWA Bulletin 4865, Murdoch University, <u>http://researchlibrary.agric.</u> <u>wa.gov.au/cgi/viewcontent.cgi?article=1042&context=bulletins</u>
- Cameron, J, Storrie, A (2014) Summer Fallow Weed Management A reference manual for grain growers and advisers in the southern and western grains regions of Australia, GRDC, <u>www. grdc.com.au/GRDC-Manual-SummerFallowWeedManagement</u>
- Carpenter, D. NSWDPI, Pulse Point Phytophthora root rot of lupins, <u>http://archive.dpi.nsw.gov.</u> <u>au/\_\_\_data/assets/pdf\_file/0019/157411/pulse-point-17.pdf</u>
- Chen, Y, Dunbabin, D, Postma, J, Diggle, A, Siddique, K, Rengel, Z (2013) Modelling root plasticity and response of narrow-leafed lupin to heterogeneous phosphorus supply, UWA, <u>http://</u> <u>research-repository.uwa.edu.au/en/publications/modelling-root-plasticity-and-response-</u> <u>of-narrowleafed-lupin-to-heterogeneous-phosphorus-supply(1dc591a6-de98-4083-a220e17bda9e1381).html</u>
- Christy, B, Riffkin, P, Clough, A, Norton, R, Stott, K, O'Leary, G (2015) Crop Yield Potential Limited by Nutrient Status in the High Rainfall Zone of Southern Australia, <u>http://www.agronomy2015.</u> <u>com.au/papers/agronomy2015final00198.pdf</u>
- Collins, S (2014), Know your nematodes and set up a crop defence system in 2015, GRDC, https://grdc.com.au/Media-Centre/Media-News/West/2014/07/Know-your-nematodes-andset-up-a-crop-defence-system-in-2014
- Cornell University (2016) Northeast Region Certified Crop Adviser Study Resources, Competency Area 4: Nutrient sources, Analyses, Application Methods, <u>https://nrcca.cals.cornell.edu/</u> <u>nutrient/CA4/CA0434.php</u>
- Couchman, J, Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>www.grdc.com.au/NVT-Victorian-Winter-Crop-Summary</u>
- Couchman, J, Hollaway, K (2016) Victorian Winter Crop Summary, Department of Economic Development, Jobs, Transport and Resources, Agriculture Victoria, <u>https://grdc.com.au/resources-and-publications/all-publications/publications/2017/03/nvt-victorian-winter-crop-summary</u>
- Cowley, R, Casburn, G (2013) Reducing the Risk of Lupinosis and the Incidence of Phomopsis, NSW Department of Primary Industries, <u>http://www.dpi.nsw.gov.au/\_\_data/assets/pdf\_\_file/0010/478243/Reducing-the-risk-of-lupinosis-and-the-incidence-of-phomopsis.pdf</u>
- CropPro (2016) Identification and management of field crop diseases in Victoria, GRDC and Department of Environment and Primary Industries Victoria, <u>http://www.croppro.com.au/</u> <u>crop\_disease\_manual/</u>
- CropPro (2017), Phytophthora Root Rot of Lupins, <u>http://www.croppro.com.au/crop\_disease\_</u> <u>manual/ch09s04.php</u>
- CropPro Brown leaf spot/pleiochaeta root rot of lupins, <u>www.croppro.com.au/crop\_disease\_</u> <u>manual/ch09s02.php</u>




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FEEDBACK

Department of Agriculture and Food WA (2016) MyCrop Lupin diagnostic tool, Diagnosing aphids in narrow leafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-aphids-narrowleafed-lupins</u>

SOUTHERN

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- Dhammu, H.S, MacLeod, W.J, Roberts, C, Payne, P.L.M, Antuono, M.F (2008) Interaction of brown leaf spot with post-emergent herbicides in narrow-leafed lupins, DAFWA, <u>http://www.lupins.org/pdf/conference/2008/Agronomy%20and%20Production/HS%20Dhammu%20W%20</u> <u>MacLeod%20C%20Roberts%20P%20Payne%20and%20M%20DAntuono.pdf</u>
- DPIRD (2016), Barley Grass, <u>https://www.agric.wa.gov.au/grains-research-development/</u> <u>barley-grass</u>
- DPIRD (2016) Bean Yellow mosaic virus in lupins, <u>https://www.agric.wa.gov.au/lupins/bean-yellow-mosaic-virus-lupins</u>
- DPIRD (2016) Crop Topping Pulse Crops, <u>https://www.agric.wa.gov.au/lupins/crop-topping-pulse-crops</u>
- DPIRD (2016) Crop Weeds: Stop weed seed set, In-crop Weed Management for Seed Set Control, <u>https://www.agric.wa.gov.au/grains/crop-weeds-stop-weed-seed-set?page=0%2C5#smartpaging\_toc\_p5\_s4\_h3</u>
- DPIRD (2016) Cucumber mosaic virus in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/grains-</u> research-development/cucumber-mosaic-virus-narrow-leafed-lupins?page=0%2C1
- DPIRD (2016) Grazing stubbles and dry pasture, DAFWA, <u>https://www.agric.wa.gov.au/autumn/</u> grazing-stubbles-and-dry-pasture?page=0%2C2
- DPIRD (2016) Lupin Essentials Growing a Successful Lupin Crop, DAFWA, <u>https://www.agric.</u> wa.gov.au/lupins/lupin-essentials-%E2%80%93-growing-successful-lupin-crop
- DPIRD (2016) Lupinosis in sheep, DAFWA, <u>https://www.agric.wa.gov.au/livestock-biosecurity/</u> <u>lupinosis-sheep</u>
- DPIRD (2016) Management of aphids in Western Australian lupin crops, <u>https://www.agric.wa.gov.</u> <u>au/grains-research-development/management-aphids-western-australian-lupin-crops</u>
- DPIRD (2016) Monitor plant nutrition levels, <u>https://www.agric.wa.gov.au/mycrop/monitor-plant-</u> nutrition-levels
- DPIRD (2016) Wild Radish, https://www.agric.wa.gov.au/grains-research-development/wild-radish
- DPIRD (2017) Management and economic thresholds for native budworm, <u>https://www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm?page=0%2C1#smartpaging\_toc\_p1\_s2\_h2</u>
- DPIRD website (2016) Diagnosing redlegged earth mite, <u>https://www.agric.wa.gov.au/mycrop/</u> <u>diagnosing-redlegged-earth-mite</u>
- DPIRD website (2016) Identification and control of pest slugs and snails for broadacre crops in Western Australia, <u>www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-andsnails-broadacre-crops-western-australia</u>
- DPIRD website (2016) Managing insects, weeds and disease in albus lupin variety Andromeda, <u>https://www.agric.wa.gov.au/lupins/managing-insects-weeds-and-disease-albus-lupin-variety-andromeda</u>
- DPIRD website (2016) 'Western Australian lupin industry': <u>https://www.agric.wa.gov.au/grains-</u> research-development/western-australian-lupin-industry
- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Diagnosing phomopsis stem and pod blight in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-phomopsis-stem-andpod-blight-narrow-leafed-lupins</u>
- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Diagnosing anthracnose in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-anthracnose-narrow-leafed-lupins</u>
- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Diagnosing Bean yellow mosaic virus non necrotic in narrow-leafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-beanyellow-mosaic-virus-non-necrotic-narrow-leafed-lupins</u>





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DPIRD-GRDC (2016) MyCrop Diagnostic Tool – Diagnosing boron deficiency in narrowleafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-boron-deficiency-narrowleafed-lupins</u>

SOUTHERN

IOVEMBER 2017

- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Diagnosing brown spot in narrow-leafed lupins, https://www.agric.wa.gov.au/mycrop/diagnosing-brown-spot-narrow-leafed-lupins
- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Diagnosing manganese deficiency in narrowleafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-manganese-deficiencynarrow-leafed-lupins</u>
- DPIRD-GRDC (2016) DAFWA MyCrop diagnostic tool Diagnosing pleiochaeta root rot in narrow-leafed lupins, <u>www.agric.wa.gov.au/mycrop/diagnosing-pleiochaeta-root-rot-narrow-</u> <u>leafed-lupins</u>
- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Diagnosing potassium deficiency in narrowleafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-potassium-deficiency-narrowleafed-lupins</u>
- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Diagnosing rhizoctonia bare patch in grain legumes, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-bare-patch-grain-legumes-0</u>
- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Diagnosing rhizoctonia hypocotyl rot in narrowleafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-rhizoctonia-hypocotyl-rotnarrow-leafed-lupins</u>
- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Diagnosing sclerotinia collar rot in narrowleafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-sclerotinia-collar-rot-narrowleafed-lupins</u>
- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Diagnosing sulphur deficiency in narrowleafed lupins, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-sulphur-deficiency-narrowleafed-lupins</u>
- DPIRD-GRDC (2016) MyCrop Diagnostic Tool Lupins, <u>https://www.agric.wa.gov.au/lupin-</u> <u>diagnostic-tool</u>
- Dracup, M, Thompson, B (2000) Narrow Leafed Lupins with Restricted Branching, DAFWA, CLIMA, <u>http://aob.oxfordjournals.org/content/85/1/29.full.pdf+html</u>
- Dracup, M. Kirby, E.J.M (1996) University of Western Australia, Lupin: Development Guide, <u>trove.nla.gov.au/work/21902398</u>
- Freeman, M & A (2005) Information Note Temperate Pulse Viruses: BYMV, Department of Environment and Primary Industries Horsham, Agriculture Victoria, <u>http://agriculture.vic.</u> <u>gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/</u> <u>temperate-pulse-viruses-bean-yellow-mosaic-virus-bymv</u>
- Gazey, C, Davies, S (2009) Soil Acidity A guide for WA farmers and consultants, DAFWA, <u>https://www.wheatbeltnrm.org.au/sites/default/files/knowledge\_hub/documents/Soil-acidity-farmers-guide-Bulletin-4784-for-screen.pdf</u>
- GRDC (2008) Grain Legume Handbook Pulses as Stockfeed, GRDC, <u>https://grdc.com.au/uploads/documents/10%20Pulses%20as%20Stockfeed.pdf</u>
- GRDC (2009) Common sowthistle and flaxleaf fleabane Understanding the weed's lifecycles for management strategies that work, GRDC, <u>https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2009/09/COMMON-SOWTHISTLE-AND-FLAXLEAF-FLEABANE-UNDERSTANDING-THE-WEEDS-LIFECYCLES-FOR-MANAGEMENT-STRATEGIES-THAT-WORK</u>
- GRDC (2013) Fact Sheet 'Better Fertiliser Decisions for Crop Nutrition', <u>www.grdc.com.au/</u> <u>GRDC-FS-BFDCN</u>
- GRDC (2014) Fact Sheet Nitrogen fixation of crop legumes: basic principles and practical management, <u>www.grdc.com.au/GRDC-FS-NFixation-Legumes</u>

GRDC (2014) Fact Sheet – Wild radish, www.grdc.com.au/GRDC-FS-WildRadishManagement





TABLE OF CONTENTS

FEEDBACK

GRDC (2014) Integrated Weed Management Manual: www.grdc.com.au/IWMM

- GRDC (2015) Fact Sheet Pre-harvest Herbicide Use, <u>www.grdc.com.au/GRDC-FS-</u> <u>PreHarvestHerbicide</u>
- GRDC (2015) Tips and Tactics Plant Parasitic Nematodes (Southern Region), GRDC, <u>https://grdc.com.au/Resources/Bookshop/2010/10/Plant-Parasitic-Nematodes-Fact-Sheet-Southern-Western-Region</u>

SOUTHERN

IOVEMBER 201

- GRDC (2015) Tips and Tools Root Lesion Nematodes Western Region, GRDC, <u>www.grdc.com.</u> <u>au/TT-RootLesionNematodes</u>
- GRDC (2016) Integrated Weed Management hub, weed profile 'Annual ryegrass', <u>https://grdc.</u> com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/annual-ryegrass
- GRDC (2016) Integrated Weed Management hub, weed profile 'Barley grass', <u>https://grdc.com.</u> <u>au/resources-and-publications/iwmhub/common-weeds-of-cropping/barley-grass</u>
- GRDC (2016) Integrated Weed Management hub, weed profile 'Brome grass', <u>https://grdc.com.</u> <u>au/resources-and-publications/iwmhub/common-weeds-of-cropping/brome-grass</u>
- GRDC (2016) Integrated Weed Management hub, weed profile 'Common sowthistle', <u>https://grdc.</u> <u>com.au/resources-and-publications/iwmhub/common-weeds-of-cropping#profiles</u>
- GRDC (2016) Integrated Weed Management hub, weed profile 'Indian hedge mustard', <u>https://</u> <u>grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/indianhedge-mustard</u>
- GRDC (2016) Integrated Weed Management hub, weed profile 'Vulpia', <u>https://grdc.com.au/</u> resources-and-publications/iwmhub/common-weeds-of-cropping#profiles
- GRDC (2016) Integrated Weed Management hub, weed profile 'Wild oats', <u>https://grdc.com.au/</u> resources-and-publications/iwmhub/common-weeds-of-cropping/wild-oats
- GRDC (2016) Integrated Weed Management hub, weed profile 'Wild radish', <u>https://grdc.com.au/</u> resources-and-publications/iwmhub/common-weeds-of-cropping/wild-radish
- GRDC (2016) Integrated Weed Management hub, weed profile 'Wireweed', <u>https://grdc.com.au/</u> resources-and-publications/iwmhub/common-weeds-of-cropping/wireweed
- GRDC (2016) Tips and Tactics Rhizoctonia Western Region, www.grdc.com.au/TT-Rhizoctonia
- GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, <u>www.grdc.com.au/GRDC-FS-</u> <u>PreHarvestHerbicide</u>
- GRDC Grain Legume Handbook (2008), www.grdc.com.au/grainlegumehandbook
- GRDC-Queensland Government, IPM Guidelines for Grains, <u>http://ipmguidelinesforgrains.com.</u> <u>au/wp-content/uploads/Etiella.pdf</u>
- GRDC Grains Legume Handbook, 2008, <u>https://grdc.com.au/resources-and-publications/all-publications/2008/03/2008-grains-legume-handbook</u>
- GRDC Tips and Tactics Rhizoctonia (2015), <u>https://grdc.com.au/uploads/documents/GRDC-FS-RhizoctoniaSW.pdf</u>
- GRDC Tips and Tactics 'Legumes and Nitrogen Fixation': <u>https://grdc.com.au/tt-legume-n-fixation</u>
- Hawthorne, W (2006) Pulses nutritional value and their role in the feed industry, Pulse Australia, <u>http://www.feedgrainpartnership.com.au/items/927/Pulses%20Nutritional%20Value%20</u> <u>and%20Their%20Role%20in%20the%20Feed%20Industry.pdf</u>
- HerbiGuide, Annual Ryegrass, <u>http://www.herbiguide.com.au/Descriptions/hg\_Annual\_Ryegrass.htm</u>
- HerbiGuide, Wild Mustard, <u>http://www.herbiguide.com.au/Descriptions/hg\_Indian\_</u> <u>Hedge\_Mustard.htm</u>

HerbiGuide, Wild Oats, http://www.herbiguide.com.au/Descriptions/hg\_Wild\_Oat.htm

HerbiGuide, Wireweed, <u>http://www.herbiguide.com.au/Descriptions/hg\_Wireweed.htm</u>





FEEDBACK

TABLE OF CONTENTS

Lindbeck, K (NSW Department of Primary Industries, Wagga Wagga Agricultural Institute, Wagga Wagga, NSW), Moore, K (NSWDPI Agricultural Institute, Calala, NSW), Richards, M & O'Connor, G (NSWDPI Agricultural Institute, Wagga Wagga, NSW) (2017), The watch outs for pulse diseases in 2017, <u>https://grdc.com.au/resources-and-publications/grdc-update-papers/</u> <u>tab-content/grdc-update-papers/2017/02/the-watch-outs-for-pulse-diseases-in-2017</u>

SOUTHERN

IOVEMBER 2017

- Lupins.org (2016) website Banding manganese fertiliser for lupins, <u>http://www.lupins.org/</u> production/#farming
- McBride, MB (1981) Forms and Distribution of Copper in Solid and Solution Phases of Soil, Copper in Plants and Soil, Golden Jubilee International Symposium, Murdoch University, <u>http://www.croppro.com.au/resources/Review%20Copper%2026082013.pdf</u>
- McKay, A (2006) Fungicide Control of Rhizoctonia Part B Syngenta, SARDI, University of SA, CSIRO Adelaide, DAFWA, <u>http://projects.grdc.com.au/projects.php?action=view\_project&project\_id=653</u>
- Murray, D, Clarke, M and Ronning, D (2013). The current and potential costs of invertebrate pests in grain crops, Grains Research and Development Corporation, <u>https://grdc.com.</u> <u>au/\_\_\_\_\_data/assets/pdf\_file/0026/159281/grdcreportcurrentpotentialcostsinvertebratepests-feb2013pdf.pdf.pdf</u>
- National Land and Water Resources Audit (2008) The National Land and Water Resources Audit Final Report: 2002-2008, <u>http://lwa.gov.au/products/pn22042</u>
- New South Wales Department of Primary Industries 'Windrowing lupins': <u>http://www.dpi.nsw.gov.au/content/agriculture/broadacre/winter-crops/pulses/lupins/windrowing-lupins</u>
- Patterson, R.A (2014) GRDC Grains Research Update Paper 'Brown manure as a farm risk strategy', <u>https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/02/</u> <u>Brown-manure-as-a-farm-risk-strategy-a-whole-farm-perspective</u>
- Peoples, M, Swan, T, Goward, L, Hunt, J, Hart, R, Hart, B (2015) Legume effects on available soil nitrogen and comparisons of estimates of the apparent mineralisation of legume nitrogen, CSIRO, Hart Bros Seeds, FarmLink Research, <u>http://www.agronomy2015.com.au/papers/ agronomy2015final00161.pdf</u>
- Peoples, M, Swan, T, Goward, L, Hunt, J, Li Guangdi Li, Harris, R, Ferrier, D, Browne, C, Craig, S, Van Rees, H, Mwendwa, J, Pratt, T, Turner F, Potter, T, Glover, A, Midwood, J (2015) Legume effects on soil N dynamics – comparisons of crop response to legume and fertiliser N, CSIRO, NSW DPI, Birchip Cropping Group, CropFacts, Central West Farming Systems, FarmLink, MacKillop Farm Management Group, Yeruga Crop Research, Riverine Plains Inc, Southern Farming Systems, <u>https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/Legume-effects-on-soil-N-dynamics--comparisons-of-crop-response-tolegume-and-fertiliser-N
  </u>
- Pulse Australia (2016). Australian sweet lupin production 2010-11 to 2015-16, <u>http://www.pulseaus.</u> <u>com.au/storage/app/media/industry/AU-lupin-exports.pdf</u>
- Pulse Australia (2016) Australian Pulse Bulletin, Desiccation and Crop-topping in Pulses, http://www.pulseaus.com.au/growing-pulses/publications/desiccation-and-croptopping
- Pulse Australia, (1 August 2016) Australian Pulse Standards 2016/17, Lupins, Angustifolius minimum receival standards farmer dressed parameter requirements, <u>http://pulseaus.com.</u> <u>au/storage/app/media/markets/20160801\_Pulse-Standards.pdf</u>
- Pulse Australia, <u>www.pulseaus.com.au/growing-pulses/publications/wide-rows-and-</u> <u>stubble-retention</u>
- Pulse Australia, www.pulseaus.com.au/storage/app/media/crops/2007\_Lupins-SA-Vic.pdf
- Pulse Australia Australian Pulse Crop Forecast (June, 2016): <u>http://www.pulseaus.com.au/</u> <u>storage/app/media/industry/20160613\_AU-pulse-crop-forecast.pdf</u>
- Pulse Breeding Australia (2016) PBA Varieties and brochures, <u>www.grdc.com.au/Research-and-Development/Major-Initiatives/PBA/PBA-Varieties-and-Brochures</u>
- Pulse Breeding Australia (2016) Spring 16 Update, Pulse Australia, <u>http://us11.campaign-archive1.</u> <a href="com/?u=27b5ae43edef0263cf76b7e1a&id=03f57ec7e6&e=827de026a3">com/?u=27b5ae43edef0263cf76b7e1a&id=03f57ec7e6&e=827de026a3</a>





FEEDBACK

## TABLE OF CONTENTS

Reddy, T, Reddi, G (1997) Mineral nutrition, manures and fertilizers. In Principles of Agronomy. pp.

SOUTHERN

OVEMBER 2017

- Regina Belski (2011) A little lupin improves the bread of life. University of Western Australia, http://www.news.uwa.edu.au/201106133641/research/little-lupin-improves-bread-life
- Reithmuller (2008) Successful lupin harvesting in Western Australia A review. Lupins. Org conference paper.
- SARDI (2017), Disease Risk Map, P. Penetrans, <u>http://pir.sa.gov.au/\_\_\_data/assets/</u> <u>image/0003/293142/Australia\_P\_penetrans\_map\_2016.jpg</u>

204-256. Kalyani Publishers, Ludhiana, India

- Scott BJ, Martin P and Riethmuller GP, (2013), Row spacing of winter crops in broad scale agriculture in southern Australia: <u>https://www.csu.edu.au/research/grahamcentre/</u> <u>publications/monograph/row-spacing-monograph</u>
- Soil Quality.org.au 'Fact Sheets Benefits of Retaining Stubble WA': <u>http://www.soilquality.org.</u> <u>au/factsheets/benefits-of-retaining-stubble</u>

## Source: lupins.org/feed

- South Australian Research and Development Institute (2016) Sowing Guide, SARDI, <u>http://www.nvtonline.com.au/wp-content/uploads/2016/03/SA-sowing-guide-2016-lo-res.pdf</u>
- Summit Fertilizers website (2016) Calcium hub, <u>www.summitfertz.com.au/research-and-agronomy/calcium.html</u>
- Thomas, G (2004) Advanced management strategies for control of anthracnose and brown spot in lupins, GRDC Final Report, <u>http://finalreports.grdc.com.au/DAW665</u>
- Thomas, G, Beard, C (2015) Mingenew Irwin Group Presentation, <u>http://www.mig.org.au/</u> author/zoe/page/3/
- University of Adelaide, AgriBio Agriculture Victoria, Latrobe University, CSIRO (2017), Legume inoculant application methods: effects on nodulation patterns, nitrogen fixation, crop growth and yield in narrow-leaf lupin and faba bean, <u>https://link.springer.com/article/10.1007/s11104-017-3317-7</u>
- Walker, J, Hertel, K, Parker, P, Edwards, J (2010) Lupin Growth and Development, Industry and Investment NSW, <u>http://www.dpi.nsw.gov.au/\_\_\_data/assets/pdf\_file/0006/516183/Procrop-lupin-growth-and-development.pdf</u>
- Walsh, M, Aves, C, Powles, S (2014) Evaluation of harvest weed seed control systems, AHRI, Nineteenth Australasian Weeds Conference paper, 4 GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, <u>http://caws.org.au/awc/2014/awc201412881.pdf</u>
- Watt, S (2016) AGT Brings lupins into its fold, GRDC Ground Cover magazine, <u>https://grdc.com.</u> <u>au/Media-Centre/Ground-Cover/Ground-Cover-Issue-122-May-Jun-2016/AGT-brings-lupinsinto-its-fold</u>
- White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, <u>http://researchlibrary.agric.wa.gov.au/cgi/viewcontent. cgi?article=1009&context=bulletins</u>
- Wilhelm, N, Davey, S (2016) Detecting and managing trace element deficiencies in crops, 2016 GRDC Grains Research Update paper, <u>https://grdc.com.au/Research-and-</u> <u>Development/GRDC-Update-Papers/2016/02/Detecting-and-managing-trace-element-</u> <u>deficiencies-in-crops</u>

