SOUTHERN
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GRDC GROWNOTES™

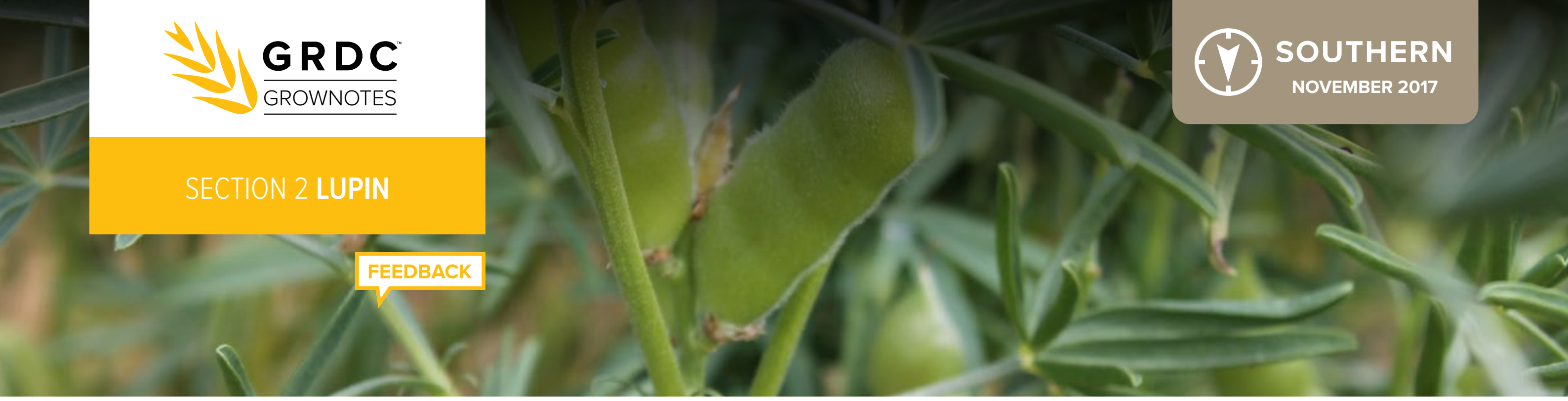
GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

LUPIN

SECTION 2

PLANTING

OVERVIEW | INOCULANTS | TIME OF SOWING | TILLAGE SYSTEMS | ROW SPACING | SEEDING RATES | SOWING DEPTH



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 $CaCl_2$), 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.

MORE INFORMATION

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

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

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

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

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

FEEDBACK

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

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/s11104-017-3317-7[2].

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

2 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, https://link.springer.com/article/10.1007/s11104-017-3317-7

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.

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 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.[4]

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), www.grdc.com.au/grainlegumehandbook

4 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

Table 3: Pros and cons of wet sowing.[5]

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	

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 varieties such as PBA Jurien⚭, PBA Bateman⚭, PBA Gunyidi⚭ and PBA Barlock⚭	

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.[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.[8]

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.[9]

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.

5 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

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

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

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

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

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*.[10] 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.[11]

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.[12]

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.[13]

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.[14]

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.[15]

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.

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

11 CropPro Brown leaf spot/pleiochaeta root rot of lupins, www.croppro.com.au/crop_disease_manual/ch09s02.php

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: https://www.csu.edu.au/research/grahamcentre/publications/monograph/row-spacing-monograph

14 Pulse Australia, www.pulseaus.com.au/growing-pulses/publications/wide-rows-and-stubble-retention

15 GRDC Grain Legume Handbook (2008), www.grdc.com.au/grainlegumehandbook

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)
- 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.[16]

The formula for calculating sowing rate for lupin is:

Seeding rate (kg/ha) = Plant density (plants/m^2) x 100 seed weight (grams) x 10 / Germination percentage[17]

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'.[18]

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[19]

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.

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

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

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

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