

DOUBLING INOCULANT RATES FACT SHEET



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Improve grain legume nodulation by increasing rhizobia numbers

KEY POINTS

- Where inoculation is needed, doubling the rate of inoculant applied can improve legume nodulation, especially under adverse sowing conditions.
- Well nodulated legumes 'fix' nitrogen from the air for legume growth and benefit subsequent non-legume crops by providing N rich residues.
- Soil bacteria called rhizobia are essential for legume nodulation.
- Rhizobia must be applied as an inoculant at sowing if suitable rhizobia are not present in the soil.
- Rhizobia applied as inoculants can have a high mortality rate when introduced into dry or acidic soils or when they come into contact with some pesticides.
- In soils with $\text{pH}_{\text{CaCl}_2}$ less than 5.5, the growth of pulses (except lupin) and their rhizobia will be impaired. Consider a lime application program to increase the pH.



Photos: Dr Liz Farquharson.

Introduction

Growing legumes in a crop rotation provides an opportunity for increasing soil nitrogen by capitalising on the symbiotic relationship between the plant's root system and soil bacteria known as rhizobia. The biological process of fixing nitrogen (N) occurs in specialised structures on the root called nodules. When there are insufficient rhizobia present in the soil they must be introduced in the form of an inoculant to the seed or soil at sowing to support legume nodulation.

Legumes have specific rhizobia requirements and are assigned to inoculant groups (see GRDC Back Pocket Guide for inoculating legumes). Inoculation is usually required if the legume or another in the same inoculation group has not previously

been grown in the paddock, as suitable rhizobia will not be present in the soil. The likelihood of a response to inoculation will be increased in hostile soils e.g. (below $\text{pH}_{\text{CaCl}_2}$ 5.5) even where the legume has been grown previously.

Sufficient rhizobia need to be alive on or near the seed at germination to multiply around the root for good nodulation. Increasing application rates of peat inoculant on seed increases the likelihood that sufficient rhizobia will survive on the seed until plant germination occurs. Research has shown that double the recommended inoculant rate consistently improves nodulation (Figure 1).

Care must be taken if growers intend to inoculate seed which has been treated with certain pesticides. Where application of fungicides containing

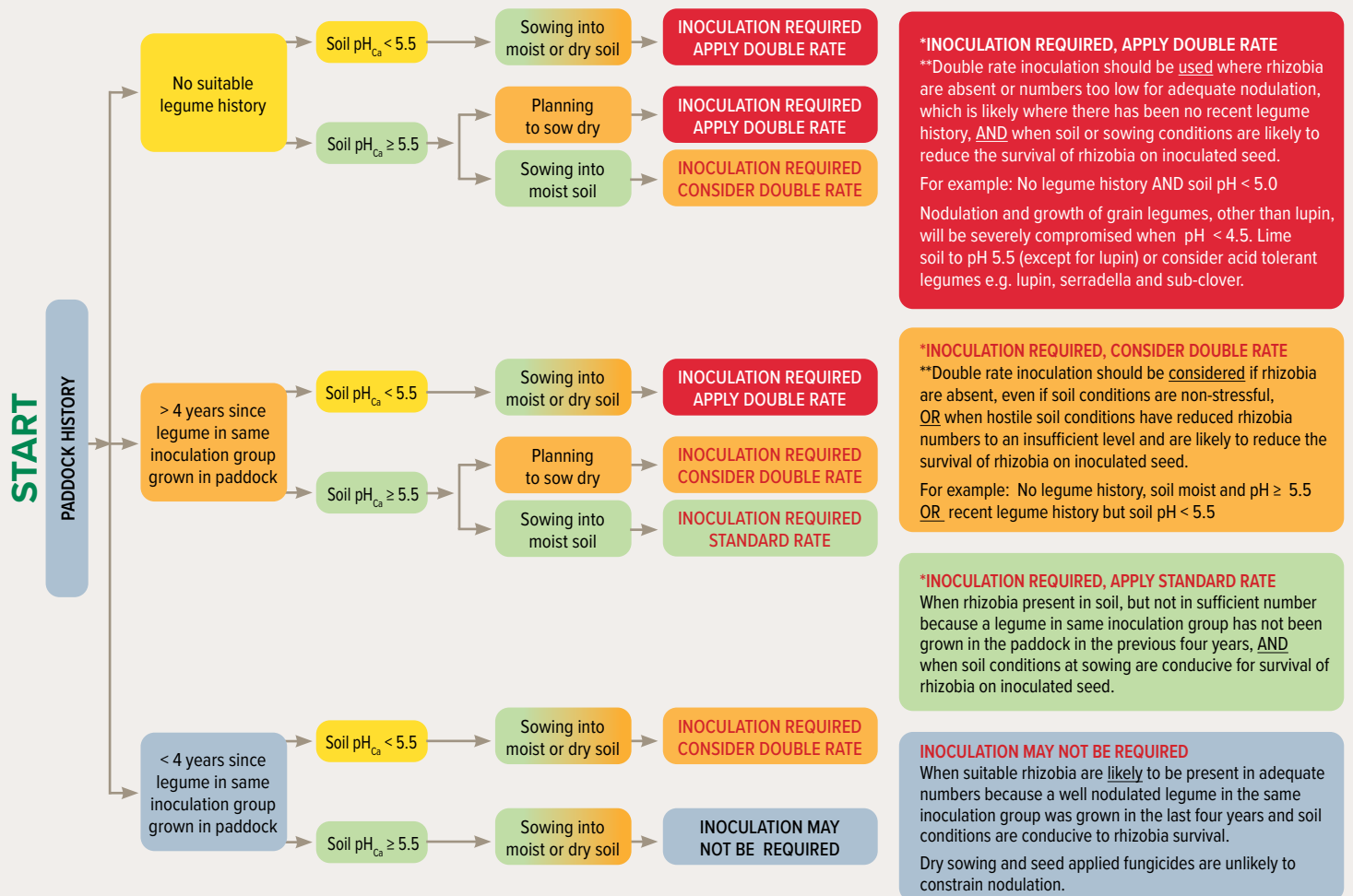
thiram or metalaxyl is necessary, the rhizobia are best applied to seed as close to sowing as is possible and sown into moist soil. Alternatively granular inoculant may provide a better option as this reduces direct exposure of the rhizobia to the pesticide.

Inoculant rates explained

Nodulation can be improved for grain legume crops if the number of rhizobia is increased, especially in adverse soil conditions (e.g. acid soils, dry sowing). The number of soil rhizobia needed for prompt nodulation lies somewhere between 100 and 1000 rhizobia per gram of soil or a minimum of between 10,000 (small seeded) and 100,000 (large seeded) rhizobia per seed when applied as inoculant. But doubling these numbers provides a buffer where conditions are unfavourable to rhizobia survival.

Inoculant - standard or double rates

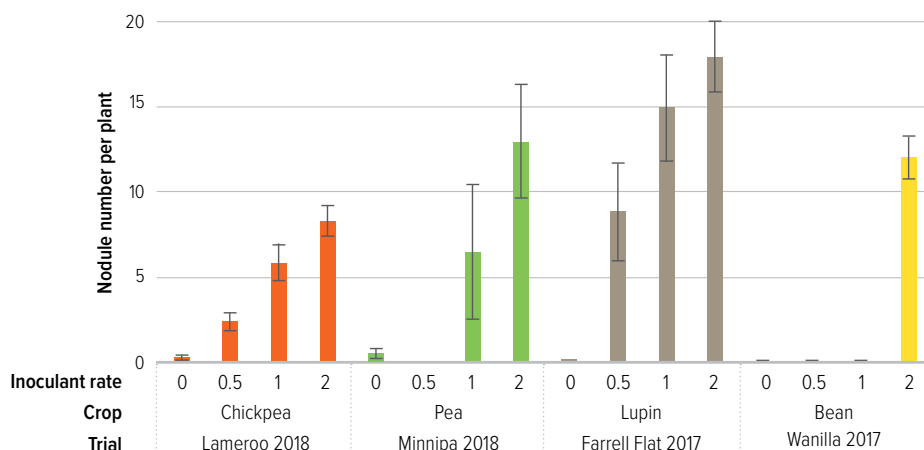
Refer to the GRDC Back-Pocket Guide (see Useful Resources) for Inoculating legumes to aid your decision making. The considerations for doubling inoculant rate of peat slurry on seed are similar to those used for determining whether inoculation is required in the first instance:



* Inoculation requirement for legumes in the E and F inoculation groups (faba bean, lentil, field pea and vetch) can be measured using PREDICTA rNod provided by SARDI. Tests for Group G and S, and N are under development. Rhizobia levels insufficient for adequate nodulation if < 250 rhizobia/g soil. Rhizobia levels adequate and inoculation response unlikely if >1000 rhizobia/g soil.

** For double rate inoculation add twice the amount of peat to the same amount of water recommended for single rate. A small test batch is recommended to confirm the inoculated seed is unlikely to cause seeder blockages, especially with smaller seeded legumes.

FIGURE 1. Nodule number responses in hostile sowing conditions, shown with varying rates (0, 0.5, 1, 2 times standard rate) of peat inoculant applied as slurry on seed.



Recommended inoculant rates vary by inoculant type and formulation, reflecting the different concentration of rhizobia in the different products which ranges between 10 million and 1000 million per g of inoculant, for granules and for peat inoculants respectively. Growers are advised to seek advice from their supplier or agronomist to confirm application rates to ensure that recommended levels of rhizobia are met or exceeded.

In recent years, inoculant products that meet or exceed the voluntary National Code of Practice under the Australian Inoculants Research Group (AIRG) have been labelled with the 'Green Tick Logo'. The presence of this logo on inoculants indicates that the products have been subject to independent quality control, and meet or exceed industry benchmarks for rhizobia number and quality.

Inoculant formulations

Peat



- Suitable for double rate application
- High numbers of rhizobia per gram product mean double rate application is cost effective



- AIRG Green Tick Logo on peat inoculants indicates they have been independently tested for quality assurance
- Consistent nodulation improvements when applied at double recommended rate, especially under dry sowing or acid soil conditions
- For double rate use twice the inoculant in the same amount of water as single rate. Do a small batch test first with the seeder to avoid blockages, especially with smaller seeded legumes
- Some seed-applied chemicals (fungicides containing thiram) are detrimental to rhizobial survival when peat is applied to seed



Granules



- Multiple granule formulations are available
- Have fewer rhizobia per gram of product than peat, therefore must be applied at higher rates
- AIRG Green Tick Logo indicates if granules are independently tested for quality assurance
- Granular formulations can provide good nodulation under dry sowing conditions
- Granules allow separation of inoculant from seed applied chemicals

Freeze-Dried



- Suitable for sowing into moist soils
- Can be applied at double rate if sowing legume for the first time
- AIRG Green Tick Logo indicates independently tested for quality assurance
- Not suitable for use when dry sowing
- Do not use in tank mixes with pesticides, fertilisers or trace elements
- Recommended to be sown within five hours of seed application

Photo: Dr Liz Farquharson.



Doubling the rate of inoculant when sowing in dry or acidic soils can produce visible results in crop biomass. This bean crop shows well-nodulated beans (left) and poorly nodulated beans (right).

FREQUENTLY ASKED QUESTIONS

How long can I keep seed once inoculated?

Rhizobia numbers on seed are highest immediately after inoculation and numbers decline rapidly in the first few hours after inoculation. In general, growers should sow legume seed within 24 hours of being inoculated. Where peat inoculants are applied to seed coated with pesticides, sow within six hours where possible. Seed inoculated with freeze dried inoculants are recommended to be sown within five hours of application.

Why do you recommend doubling the inoculation rate for soils under pH 5.5?

Acidic soils with a pH_{CaCl_2} of less than 5.5 can substantially reduce the survival of rhizobia on most legumes. In such acidic conditions, most legumes (except lupin) may require inoculation each time the crop is grown. Doubling the rate of inoculant can improve nodulation by ensuring enough rhizobia survive until seed germination in acidic soil conditions.

What are the ideal conditions for sowing inoculated seed?

Rhizobia are very sensitive to environmental stresses and can be easily killed by exposure to heat, extreme pH, dry soil conditions and toxic chemicals. Inoculated legumes should ideally be sown into moist soil or just prior to a breaking rain to ensure best chances of survival. Extended dry periods of more than seven days can impact rhizobia survival and growers should always double the inoculation rate under these conditions.

How can paddock history impact inoculation decisions?

Crop type, legume type and time since previous inoculation can affect the decision to inoculate. In ideal conditions, rhizobia populations can maintain adequate levels in the soil for several seasons. However, acidic soils with a pH_{Ca} of less than 5.5 measured in calcium chloride can substantially reduce the survival of rhizobia for most legumes. In such acidic conditions, most legumes will require inoculation each time the crop is grown.

Can I double the rate of granular inoculant?

Limited research has been conducted on the benefits of increasing the rate of granular inoculant. Compared to peat, granules are expensive based on the number of rhizobia delivered per gram of product.

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Note: references to pH in this document refer to pH measured in calcium chloride ($CaCl_2$)

USEFUL RESOURCES

GRDC Tips and Tactics - Legumes and nitrogen fixation <https://grdc.com.au/tt-legume-n-fixation>

GRDC Inoculating legumes – A practical guide <https://grdc.com.au/GRDC-Booklet-InoculatingLegumes>

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

Ground Cover – Lifting rates could improve nodulation success <https://grdc.com.au/resources-and-publications/groundcover/groundcover-138-january-february-2019/lifting-rates-could-improve-nodulation-success>

Paddock Practices: 10 Dos and Don'ts when inoculating legumes – GRDC <https://grdc.com.au/news-and-media/news-and-media-releases/south/2020/april/paddock-practices-10-dos-and-donts-when-inoculating-legumes>

Australian Inoculants Research Group - <https://www.dpi.nsw.gov.au/agriculture/soils/australian-inoculants-research-group>

MORE INFORMATION

Liz Farquharson
South Australian Research and Development Institute (SARDI)
08 8429 2243
liz.farquharson@sa.gov.au

Ross Ballard
South Australian Research and Development Institute (SARDI)
08 8429 2217
ross.ballard@sa.gov.au

Maarten Ryder
University of Adelaide
0409 696 360
maarten.ryder@adelaide.edu.au

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