# INOCULATING LEGUMES

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

NATIONAL

# THE BACK POCKET GUIDE

# Rhizobia


- Rhizobia are living micro-organisms (also called root-nodule bacteria)
- Nodules on legume roots contain rhizobia, which fix nitrogen from the atmosphere
- Each type of legume is nodulated by a specific type of rhizobia, which are identified as belonging to different inoculant groups
- Rhizobia in inoculants do not survive well in high temperatures (over 30°C) or drying conditions that lead to desiccation
- Different legume–rhizobia associations will tolerate different soil conditions. Generally rhizobia preferences are similar to those of the legume host
  - medic, pea, faba bean and chickpea rhizobia prefer neutral to alkaline soils ($pH_{Ca}$ 6.0 – 7.5)
  - lupin rhizobia tolerate acid soils ($pH_{Ca}$ less than 6.5)

**Example of a functional nodule of soybean.**
PHOTO: NATALIE MOORE, NSW DPI.

DNA tests can be used to measure rhizobia number in soils.
PHOTO: GRDC.

# Measuring rhizobia in soil

- Rhizobia numbers in individual paddocks vary greatly, they are affected by soil type, legume history and management practices
- PREDICTA rNod test measures the rhizobia that nodulate pulses in the following inoculation groups; Groups E and F (field pea, faba and broad bean, lentil, vetch and lathyrus), Group N (chickpea) and Groups G and S (lupin and serradella)
- Use the sampling protocol for collecting PREDICTA®B soil samples. Soil samples are best collected pre-season from February
- If paddocks have multiple soils types then each soil type should be sampled separately
- The test report provides a guide to the inoculation requirement for pulses associated with each of the inoculation groups measured
- Further information: pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b

PREDICTA rNod
Group E & F root nodule bacteria

| Intended crop | Soil pH(Ca): | Soil texture |
|---|---|---|
| Beans | 7.38 | Loam |

Inoculation Requirement**

| BENEFICAL ORGANISMS | RESULT | | High | Medium | Low | Nil |
|---|---|---|---|---|---|---|
| Rhizobium Group E & F | 4.1 | log(rhizobia)/g soil | | | | |

# Inoculation benefits

- Inoculated legumes will fix up to 25kg of nitrogen per tonne of legume shoot dry matter
- Low soil nitrate levels, good nodulation and agronomic practices that promote high legume production all help increase nitrogen (N) inputs from N fixation
- Decomposing legume residues are a good source of slow-release nitrogen for a following crop
- Economic benefits of legumes in crop production systems can be substantial, both from N fixation and the disease-break effect
- For example: inoculated faba beans in Western Victoria yielded 2.7t/ha (1t/ha more than the uninoculated crop) and added 180kg/ha of extra fixed N to the soil

**Non-nodulated soybean (right front) and well-nodulated soybean (left rear).**
PHOTO: N MOORE, NSW DPI.

# Getting inoculation right

- Use inoculants that provide evidence of independent quality control, such as the Green Tick Logo
- Use the correct inoculant group for the legume
- Inoculants contain live bacteria: make sure they are kept in moderate temperatures (between 4 and 10°C) away from sunlight and chemicals
- Sow freshly inoculated seed as soon as possible and within 24 hours for peat and 5 hours for freeze-dried formulations
- Use clean potable water for dilution when using liquids or slurries, and make sure holding tanks are free from chemical and fertiliser residues


- Many pesticides, mineral and organic fertilisers are toxic to rhizobia and should never be mixed with rhizobia
- Rhizobia are incompatible with many seed pickles or dressings (see *Inoculating Legumes: Practice and Science, 2022,* and manufacturer's guidelines). Always apply the seed dressing first and allow it to fully dry before applying the rhizobia as a second process. Sow as soon as possible after inoculation
- Always use inoculants before their expiry date
- Reseal opened bags of peat inoculant and use them within two weeks of first opening the bag
- Inoculant formulations vary in the number of rhizobia they contain. Ensure they are applied at the rate recommended by the manufacturer

Registered trademark for inoculant quality – the Green Tick Logo.

# Using different inoculant formulations

| | Peat | Freeze-dried | Granular | Liquid |
|---|---|---|---|---|
| **Description** | Finely ground sterilised peat containing a high density of rhizobia | Powder containing a very high density of rhizobia | Granules of peat or clay or a mixture; contain a lower density of rhizobia | High density of rhizobia. Only available for soybean in Australia |
| **Storage** | Store between 4 and 10°C | Refrigerate at 4°C<br>DO NOT FREEZE | Store in a cool and dry place, raised off the floor and away from direct sunlight | Store at 4°C |
| **Common application** | Applied as a slurry to seed or liquid suspension in furrow | Applied with a protecting agent to seed or liquid suspension in furrow | Granules are delivered in furrow at sowing. Suitable for sowing into moist or dry soils | Can be applied on-seed or in-furrow |
| **Using additives** | If used, ensure adhesive solutions are cooled before rhizobia are added. Generally NOT COMPATIBLE with mineral and organic fertilisers and pesticides; check manufacturer's guidelines | Generally NOT COMPATIBLE with mineral and organic fertilisers and pesticides; check manufacturer's guidelines | Check inoculant manufacturer's compatibility guidelines | Do not use in tank mixes with pesticides, fertilisers or trace elements |
| **Sowing** | Sow the seed within 24 hours of inoculation into moist soil | Sow treated seed into moist soil within 5 hours of application | For best results, apply granules in-furrow rather than broadcast. Granules can be sown into moist or dry soil | Sow within five hours of seed application, do not expose seed to direct sunlight |

# Seed coating in practice

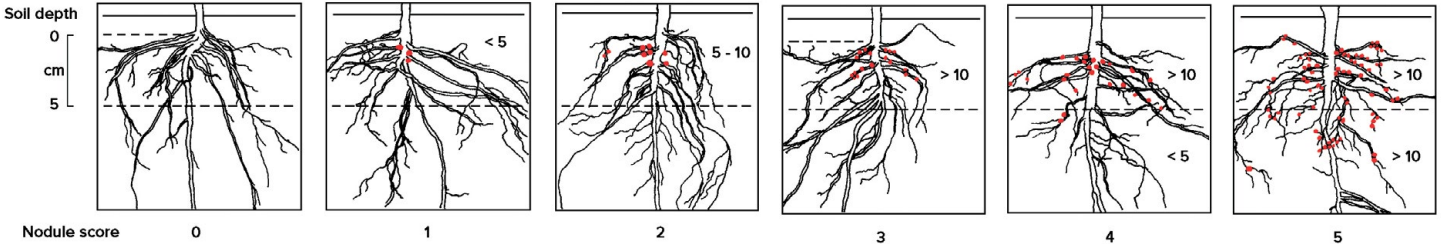

- Rates of inoculant application, i.e. volumes and weights of inoculant, water and seed, are given on inoculant packets
- Peat formulation is made into a slurry using clean potable water in a clean drum or tank and mixing well. Note: Chemical and fertiliser residues can be toxic to rhizobia
- For pasture seed, an adhesive is often added to the slurry
- Freshly prepared inoculant slurry can be applied to the grain legume seed while going up a slow-moving auger into a bin
- Pasture seed, being small, can be coated in a concrete mixer or by mixing with a shovel on a concrete floor
- Most temperate pasture seed is best coated with fine lime (builders' and slaked lime must not be used)
- Freeze-dried inoculant can be applied in the same way as peat slurry, as per manufacturer's instructions
- Allow slurry-treated seed to dry before filling air-seeders to prevent 'bridging' in the seeder bin

**Peat slurry inoculation of faba bean on farm – setup included spray tank with pump, liquid slurry is transferred to auger and coats seed en route to truck/seeder bin prior to sowing.** PHOTO: BELINDA CAY, AGCOMMUNICATORS.

# Assessment of nodulation

- A well-nodulated plant has nodules on the crown (where the root meets the shoot) and on the tap root and lateral roots
- Take 10 plants from each of three locations (40-50m apart) in the paddock, to cover paddock variability
- Carefully dig up plants with root systems intact and gently wash roots (e.g. in a bucket of water) to remove soil
- Cut a few nodules open: red/pink-coloured tissue indicates nodules are actively fixing nitrogen
- Desired numbers of nodules per plant at 8-10 weeks old are given in the sections of this guide for individual legume species
- Short instructional videos at: ua.edu.au/legume-inoculation

**System for scoring nodulation of legumes. 0-1 = inadequate, 2-3 = adequate, 4-5 = good**




*Source: Unkovich et al. 2008, Measuring plant associated nitrogen fixation in agricultural systems.*
*Suitable for most legumes species and can be modified for perennial species or species with higher nodulation targets for an adequate score.*

# Troubleshooting nodulation failure

- Symptoms of poor nodulation are yellowing of older leaves, yellow and/or stunted patches of plants
- Poor nodulation is difficult to remediate during the growing season. In high value crops, the application of N fertiliser could be considered to salvage some yield
- Possible other remedies (if done immediately):
  - in flood or sprinkler-irrigated fields, add slurry or liquid inoculant to the irrigation water
  - Sow a granular inoculant close to the original sowing furrow
- To improve nodulation in following seasons:

  Optimise inoculation practice
  - use the correct inoculant
  - avoid contact between inoculant and pesticides/fertilisers
  - sow seed shortly after inoculation into moist soil

  Optimise soil conditions at sowing
  - soil pH optimal for the legume
  - absence of herbicide residues
  - moist soils
  - low available soil N

**Faba beans grown at Wanilla in trials showing the difference between nodulation failure (left) and successful nodulation (right).**
PHOTO: LIZ FARQUHARSON, SARDI.

# Inoculation Groups

## Inoculation and nodulation groups

- The relationship between the rhizobia and the legume is often specific
- Legumes that are nodulated by the same species of rhizobia are assigned to the same Inoculation Group
- Some Inoculant Groups comprise a single legume (Group N - chickpea), others contain several legumes (Group E - field pea, lentil and vetch)
- The need for inoculation varies between the Inoculation Groups
- Inoculation requirement and target levels of nodulation are described in the following pages

**Sowing inoculated chickpeas (top) and a field trial at North Shields (bottom).**
PHOTOS: ALISTAIR LAWSON, AGCOMMUNICATORS, AND LIZ FARQUHARSON, SARDI.

Well-nodulated roots of chickpea.
PHOTO: ANDREW HEATH.

# Chickpea *(Cicer arietinum)*

**INOCULANT GROUP N** (STRAIN CC1192)

## Key considerations

- Chickpea has a very specific rhizobia requirement
- Rhizobia generally absent outside main growing regions
- Existing soil levels of chickpea rhizobia can be measured using a DNA test

## Inoculation method

- Peat formulation: as slurry to seed (most common) or in furrow
- Freeze-dried formulation: as slurry to seed or liquid in furrow
- Granular formulation: in furrow at sowing

## Nodulation

- After 8 weeks, 10 larger or 30 smaller nodules per plant is satisfactory

## Likely response to inoculation for sown chickpea

| | |
|---|---|
| HIGH | Chickpeas not previously grown. |
| MODERATE | Previous chickpea crop was grown more than four years ago OR<br>Legume nodulation or growth below expectation. |
| LOW | Loam or clay soils with neutral or alkaline pH and recent history of well nodulated chickpea crop in past two years. |

# Field pea, lentil, vetch

***(Pisum sativum, Lens culinaris, Vicia species)***

**INOCULANT GROUP E** (STRAIN WSM4643)

## Key considerations

- Where not previously grown, inoculate with rhizobia for effective nodulation and nitrogen fixation
- Group E rhizobia are sensitive to soil acidity
- Existing soil levels of rhizobia for legumes in the E/F inoculation groups can be measured using a DNA test

## Inoculation method

- Peat formulation: as slurry to seed (most common) or in furrow
- Freeze-dried formulation: as slurry to seed or liquid in furrow
- Granular formulation: in furrow at sowing

## Nodulation

- After 8-10 weeks, 50 pink nodules per plant is satisfactory on most soil types

## Likely response to inoculation for sown pea/ lentil/vetch

| | |
|---|---|
| HIGH | Soils with $pH_{Ca}$ below 5.5 and high summer soil temperatures (>35°C for 40 days) OR<br>Legume host (pea, faba bean, lentil, vetch) not previously grown. |
| MODERATE | No legume host (pea, faba bean, lentil, vetch) in previous four years OR<br>Prior host crop not inoculated or lacked good nodulation. |
| LOW | Loam or clay soils with neutral or alkaline pH and a recent history of host crop with good nodulation. |

**Well-nodulated roots of field pea.**
PHOTO: LIZ FARQUHARSON, SARDI.

Well-nodulated roots of faba bean.
PHOTOS: LIZ FARQUHARSON, SARDI.

# Faba bean and broad bean *(Vicia faba)*

**INOCULANT GROUP F** (STRAIN SRDI969)

## Key considerations

- Where not previously grown, inoculate with rhizobia for effective nodulation and nitrogen fixation
- Group F rhizobia are sensitive to soil acidity
- Existing soil levels of rhizobia for legumes in the E/F inoculation groups can be measured using a DNA test

## Inoculation method

- Peat formulation: as slurry to seed (most common) or in furrow
- Freeze-dried formulation: as slurry to seed or liquid in furrow
- Granular formulation: in furrow at sowing

## Nodulation

- After 8-10 weeks, 50 pink nodules per plant is satisfactory on most soil types

## Likely response to inoculation for sown faba bean and broad bean

| | |
|---|---|
| HIGH | Soils with $pH_{Ca}$ below 5.5 and high summer soil temperatures (>35°C for 40 days) OR<br>Legume host (pea, faba bean, lentil, vetch) not previously grown. |
| MODERATE | No legume host (pea, faba bean, lentil, vetch) in previous four years OR<br>Prior host crop not inoculated or lacked good nodulation. |
| LOW | Loam or clay soils with neutral or alkaline pH and a recent history of host crop with good nodulation. |

Well-nodulated lupin (top) and serradella (above).
PHOTOS: ROSS BALLARD, SARDI.

# Lupin and serradella *(Lupinus* and *Ornithopus* species*)*

**INOCULANT GROUP G** (LUPIN STRAIN WU425)

**INOCULANT GROUP S** (SERRADELLA STRAIN WSM471)

## Key considerations

- Groups G and S both nodulate lupin and serradella
- Inoculation is essential where lupin or serradella have not been grown, because sandy soils are often acutely N deficient
- Existing soil levels of group G and S rhizobia can be measured using a DNA test

## Inoculation method

- Peat formulation as slurry to seed (most common) or in furrow
- Lime pelleting of serradella recommended in all states except WA. For inoculating podded serradella: adjust liquid volumes to ensure even distribution; follow manufacturer's instructions carefully

## Nodulation after 8-10 weeks

- Lupin: crown region (top of root system) covered with nodules
- Serradella: more than 20 pink nodules per plant is satisfactory

## Likely response to inoculation for sown lupin and serradella

| | |
|---|---|
| HIGH | Lupin or serradella not previously grown in paddock. |
| MODERATE | No legume host in past four years OR<br>Previous host crop not inoculated and legume growth or nodulation below expectation. |
| LOW | Sowing in the north and central regions of the Western Australian wheat/sheep belt OR<br>Recent history (past four years) of vigorous lupin/serradella growth and good nodulation. |

Well-nodulated roots of peanut.
PHOTO: NIKKI SEYMOUR.

# Peanut *(Arachis hypogaea)*

**INOCULANT GROUP P** (STRAIN NC92)

## Key considerations

- Inoculation every season is recommended to maximise yields as native or background rhizobia compete strongly with the inoculant strain for root infection but are not as effective at fixing N

## Inoculation method

- Recommend water injection of peat or freeze-dried inoculum to prevent damage to seed from slurry coating

## Nodulation

- Peanut can form many nodules, i.e. more than 100/plant
- Satisfactory number of nodules per plant 8-10 weeks after sowing: not possible to state

## Likely response to inoculation for sown peanut

| | |
|---|---|
| HIGH | Peanut not previously grown. |
| MODERATE | Most other situations due to likely presence of poorly effective rhizobia. |
| LOW | Recent and/or intensive cultivation of peanut. |

Well-nodulated roots of mungbean.
PHOTO: NIKKI SEYMOUR.

# Mungbean and cowpea

## *(Vigna radiata, V. mungo* and *V. unguiculata)*

**INOCULANT GROUP I** (STRAIN CB1015)

### Key considerations

- Where not previously grown, inoculate with rhizobia for effective nodulation and nitrogen fixation
- Soil nitrate-N may depress nodulation and N fixation, even at relatively low levels (>20kg N/ha)

### Inoculation method

- Peat formulation: as slurry to seed (most common) or in furrow
- Freeze-dried formulation: as slurry to seed or liquid in furrow

### Nodulation

- After 6-8 weeks, more than 20 pink nodules per plant is satisfactory

### Likely response to inoculation for sown mungbean and cowpea

| | |
|---|---|
| HIGH | No previous mungbean, cowpea or other related *Vigna* species. |
| MODERATE | Most other situations due to likely presence of poorly effective rhizobia. |
| LOW | Recent and/or intensive cultivation of mungbean or cowpea. |

Well-nodulated roots of soybean.
PHOTO: NIKKI SEYMOUR.

# Soybean *(Glycine max)*

**INOCULANT GROUP H** (STRAIN CB1809)

## Key considerations

- Soybean specifically requires Group H rhizobia and will not nodulate with the same rhizobia as mungbean or cowpea
- Good agronomy and inoculation practice are needed for good yield and nitrogen fixation

## Inoculation method

- Peat formulation: as slurry to seed (most common) or in furrow
- Freeze-dried formulation: as slurry to seed or liquid in furrow
- Liquid formulation: liquid in furrow

## Nodulation

- After 8-10 weeks, more than 20 pink nodules per plant is satisfactory

## Likely response to inoculation for sown soybean

| | |
|---|---|
| HIGH | No previous soybean crop. Highly alkaline or highly acidic soils. |
| MODERATE | Soybean cultivated in paddock more than three to five years ago. |
| LOW | Recent and/or intensive cultivation of soybean. |

Well-nodulated roots of sub clover.
PHOTO: ROSS BALLARD, SARDI

# Annual clovers *(Trifolium* species*)*

(SUBTERRANEAN, BALANSA, PERSIAN, BLADDER, ARROWLEAF, ROSE, GLAND, CRIMSON, PURPLE, CUPPED AND HELMET)

**INOCULANT GROUP C** (STRAIN WSM1325)

## Key considerations

- Inoculation is essential for gland, bladder and arrowleaf clovers and recommended for all other annual clovers
- Inoculation may help overcome sub-optimal symbioses with naturalised soil rhizobia to improve establishment of sown pastures

## Inoculation method

- Most commonly applied as a slurry of peat followed by pelleting with fine lime or other suitable product
- Granular and freeze-dried inoculant formulations available
- Preinoculated (pelleted) seed is available. Check time from inoculation not more than six weeks. Freshly inoculated seed is preferred

## Nodulation

- More than 50 pink nodules per plant after 8 weeks of growth is good

## Likely response to inoculation for sown annual clovers

| | |
|---|---|
| HIGH | Gland, bladder and arrowleaf clovers should always be inoculated. All annual clovers where there is no history of clover having been grown. Soils with $pH_{Ca}$ below 5.0 and where there is tillage at pasture renovation. |
| MODERATE | No clover host in past four years and soil $pH_{Ca}$ below 5.5 OR<br>Clover present, but growth or nodulation below expectation. |
| LOW | Soils with neutral or alkaline $pH_{Ca}$ and a recent history of good clover growth and nodulation. |

Well-nodulated roots of medic.
PHOTO: ROSS BALLARD, SARDI.

# Annual medics *(Medicago* species (except strand and disc))

**INOCULANT GROUP AM** (STRAIN WSM1115)

## Key considerations

- Inoculation always recommended for burr, murex and sphere medic, sown into slightly acidic soils ($pH_{Ca}$ 5.0 to 6.0)
- Do not use Group AL inoculant because it is less effective at fixing nitrogen with some medic species in this group
- Inoculation may help overcome sub-optimal symbioses with naturalised soil rhizobia to improve establishment of sown pastures

## Inoculation method

- Most commonly applied as a slurry of peat followed by pelleting with fine lime or other suitable product
- Granular and freeze-dried inoculant formulations are available
- Preinoculated (pelleted) seed is available. Check time from inoculation. Freshly inoculated seed is preferred

## Nodulation

- 10-20 pink nodules per plant after 8 weeks of growth is good

## Likely response to inoculation for sown annual medics

| | |
|---|---|
| HIGH | Burr, sphere and murex medic sown on soils with $pH_{Ca}$ below 6.0 OR<br>No presence or history of sown or naturalised medic. |
| MODERATE | Medic present, but growth or nodulation below expectation. May be associated with the presence of sub-optimal populations of rhizobia. |
| LOW | Loam or clay soils with neutral or alkaline $pH_{Ca}$ and a recent history of vigorous medic growth and good nodulation |

Well-nodulated roots of biserrula.
PHOTO: ROSS BALLARD, SARDI.

# Biserrula *(Biserrula pelecinus)*

**INOCULANT GROUP SPECIAL** (STRAIN WSM1497)

## Key considerations

- An annual pasture legume, grown since 2001, mostly in WA but expanding in NSW
- Biserrula has a very specific rhizobia requirement
- It does not nodulate with rhizobia associated with other indigenous or cultivated legumes

## Inoculation method

- Peat-slurry lime pelleted seed or seed sown with granular inoculant
- Increased inoculation rates (above recommended rates), of one 250g packet of inoculant for 10kg seed are recommended

## Nodulation

- At least 5 large (>5mm) and 10 small nodules per plant after 8 weeks of growth is good

## Likely response to inoculation for sown biserrula

| | |
|---|---|
| HIGH | Biserrula host has not been previously grown. |
| MODERATE | No biserrula in past four years OR<br>Last host crop not inoculated or lacked 'good' nodulation near top of root system. |
| LOW | Loam or clay soils with neutral or alkaline pH and a recent history (past two years) of host crop with good nodulation. |

Well-nodulated roots of lotus.
PHOTO: RONALD YATES.

# Lotus

## *(Lotus pedunculatus (*syn. *uliginosus)* and *Lotus corniculatus)*

**INOCULANT GROUP D** (STRAIN CC829) for Greater lotus, *L. pedunculatus*
**INOCULANT GROUP SPECIAL** (STRAIN SU343) for Birdsfoot trefoil, *L. corniculatus*

### Key considerations

- A different strain of rhizobia is needed for each species of lotus, the two inoculant strains should not be interchanged
- Lotus rhizobia are moderately tolerant of soil acidity

### Inoculation method

- Most commonly applied as a slurry of peat followed by pelleting with fine lime or other suitable product
- One packet of peat inoculant (250g) will inoculate 10kg of seed
- Freeze dried formulations are available

### Nodulation

- More than 30 pink nodules per plant after 8-10 weeks of growth is good

### Likely response to inoculation for sown lotus

| | |
|---|---|
| HIGH | Lotus not previously grown. |
| MODERATE | No lotus in past four years OR<br>Prior lotus pasture not inoculated or lacked good nodulation near top of root system. |
| LOW | Loam soils with neutral pH and a recent history (past two years) of lotus with adequate nodulation. |

Well-nodulated roots of lucerne seedlings.
PHOTO: ROSS BALLARD, SARDI.

# Lucerne, strand and disc medics, melilotus (albus)

***(Medicago sativa, M. littoralis, M. tornata, Melilotus albus)***

**INOCULANT GROUP AL** (STRAIN RRI128)

**INOCULANT GROUP SPECIAL** (STRAIN SRDI736) for lucerne on acidic soils (pH<5.0)

## Key considerations

- Inoculation is always recommended for good lucerne establishment
- Do not use Group AM inoculant because it is less effective at fixing nitrogen with lucerne, strand and disc medic

## Inoculation method

- Most lucerne seed is sold preinoculated; if it is more than six months since inoculation, the seed should be reinoculated
- Due to nodulation sensitivity to low pH, coat inoculated seed with fine lime

## Nodulation

- Lucerne: At least 5 pink nodules (ideally 10-15) per plant at 8-10 weeks is good
- Strand medics often form few nodules: 5 nodules at 8 weeks are satisfactory

## Likely response to inoculation for sown lucerne, strand and disc medics, melilotus albus

| | |
|---|---|
| HIGH | Lucerne should always be inoculated at sowing. Soils with $pH_{Ca}$ below 6.0. No history or presence of sown or naturalised medic. |
| MODERATE | Medic present, but growth or nodulation below expectation. May be associated with development of sub-optimal populations of medic rhizobia in the soil. High number of rhizobia on sown seed will compete with soil rhizobia at sowing but potency will diminish after several seasons. |
| LOW | Loam or clay soils with neutral to alkaline $pH_{Ca}$ and a recent history of vigorous medic growth and good nodulation. |

# Perennial clovers *(Trifolium* species*)*

(WHITE, STRAWBERRY, RED, TALISH, ALSIKE, BERSEEM, EGYPTIAN, CLUSTER OR BALL, SUCKLING, CAUCASIAN AND KURA)

**INOCULANT GROUP B** (STRAIN TA1)

**INOCULANT GROUP SPECIAL** (STRAIN CC283b) for caucasian and kura clovers

## Key considerations

- Inoculation assists vigorous early growth of small-seeded perennial legumes
- For good nodulation, soil $pH_{Ca}$ should be greater than 5.0
- DO NOT USE Group C inoculant (WSM1325); nitrogen fixation by perennial clovers is significantly better with the Group B inoculant strain TA1

## Inoculation method

- Most perennial clover seed is sold preinoculated; if it is more than two weeks since inoculation, the seed should be re-inoculated
- For white clover, use 250g packet of peat inoculant to inoculate 25kg of seed; adjust the inoculation rate for small-seeded species

## Nodulation

- Good: at least 10 pink nodules per plant after 8-10 weeks of growth

## Likely response to inoculation for sown perennial clovers

| | |
|---|---|
| HIGH | Caucasian clover should always be inoculated. All perennial clovers where there is no history of clover having grown. Soils with $pH_{Ca}$ below 5.0 and where there is tillage at pasture renovation. |
| MODERATE | No clover host in past four years and soil $pH_{Ca}$ below 5.5. Clover present, but growth or nodulation below expectation. May be associated with development of sub-optimal populations of soil rhizobia. High numbers of rhizobia on sown seed will compete with soil rhizobia at sowing but potency will diminish after several seasons. |
| LOW | Soils with neutral or alkaline $pH_{Ca}$ and a recent history of good clover growth and nodulation. |

**Well-nodulated white clover: abundant nodules on the tap root and close to the crown.**
PHOTO: GREG GEMELL.

Well-nodulated roots of sulla.
PHOTO: RONALD YATES.

# Sulla *(Hedysarum coronarium)*

**INOCULANT GROUP SULLA SPECIAL** (STRAIN WSM1592)

## Key considerations

- It is essential to inoculate sulla as it has very specific rhizobia requirements; sulla rarely nodulates with background soil rhizobia
- Seedlings quickly develop nitrogen deficiency symptoms where nodulation is inadequate

## Inoculation method

- Most commonly applied as a slurry of peat followed by pelleting with fine lime or other suitable product
- Higher inoculation rates (above recommended rates) of one 250g packet of inoculant for 10kg seed are recommended
- Preinoculated seed has a very short shelf life and should be sown as soon as possible after inoculation. Freshly inoculated seed is preferred

## Nodulation

- Five or more large (>5 mm) nodules per plant after 8-10 weeks of growth is satisfactory

## Likely response to inoculation for sown sulla

| | |
|---|---|
| HIGH | Sulla not previously grown OR<br>Soils with $pH_{Ca}$ below 6.0. |
| MODERATE | No sulla in past four years OR<br>Growth or nodulation of previous crop below expectation. |
| LOW | Loam or clay soils with neutral or alkaline $pH_{Ca}$ and a recent history (past two years) of sulla with good nodulation. |

Well-nodulated roots of messina.
PHOTO: ROSS BALLARD, SARDI.

# Messina *(Melilotus siculus)*

**INOCULANT GROUP SPECIAL** (STRAIN SRDI554)

## Key considerations

- It is essential to inoculate messina as the saline areas where it is generally grown lack suitable rhizobia
- Messina must be inoculated with the strain SRDI554
- Messina should not be grown on soils below $pH_{Ca}$ 5.8

## Inoculation method

- Most commonly applied as a slurry of peat followed by pelleting with fine lime
- Fresh inoculation immediately before sowing recommended

## Nodulation

- More than 20 nodules per plant after 8-10 weeks of growth is satisfactory

## Likely response to inoculation for sown messina

| | |
|---|---|
| HIGH | Messina not previously grown OR<br>Soils with $pH_{Ca}$ below 6.0, salinity >8 dS/m |
| MODERATE | No messina in past four years OR<br>Growth or nodulation of previous messina below expectation. |
| LOW | Loam or clay soils with neutral or alkaline $pH_{Ca}$, low salinity levels, and a recent history (past two years) of messina or medics in AM inoculation group with good nodulation. |

Well-nodulated roots of tedera.
PHOTO: RONALD YATES, DAFWA.

# Tedera *(Bituminaria bituminosa* var. *albomarginata)*

**INOCULANT GROUP SPECIAL** (STRAIN WSM4083)

## Key considerations

- Inoculation recommended as Australian soils unlikely to contain suitable rhizobia
- Tedera must be inoculated with the strain WSM4083
- Tedera is best suited to well drained soils with $pH_{Ca} \geq 4.8$

## Inoculation method

- Use a slurry of peat followed by pelleting with fine lime
- Fresh inoculation immediately before sowing recommended

## Nodulation

- Three-month old seedlings should have 5-10 nodules per plant

## Likely response to inoculation for sown tedera

HIGH | **Tedera is a new species to agriculture in Australia and should always be inoculated.**

# Inoculant groups

**Inoculant groups for some common legume species and rate of peat inoculant applied to seed. Always check manufacturers guidelines.**

| Inoculant group | Common name of legume | Seed size | Grams of peat inoculant required to treat 1kg seed |
|---|---|---|---|
| **AL** | Lucerne, strand and disc medics<br>Sweetclover (only *Melilotus albus*) | Small | 10 |
| **AM** | Burr, barrel, snail, sphere, murex and gama medics | Medium | 5 |
| **B** | White, red, strawberry, alsike, talish, berseem/Egyptian, cluster/ball and suckling clovers | Small | 10 |
| **C** | Subterranean, bladder, rose, helmet, crimson clovers | Medium | 5 |
| | Arrowleaf, balansa, gland, purple, Persian clovers | Small | 10 |
| **D** | Greater lotus (only *Lotus pedunculatus*) | Very small | 25 |
| **E** | Field pea, pea (snow and snap peas etc), vetch (common, woolly pod, bitter & purple) | Large | 2.5 |
| | Lentil | Medium | 5 |
| **F** | Faba, broad and tick bean | Large | 2.5 |
| **G** | Narrow-leaf, Mediterranean white, yellow and sandplain lupins | Large | 2.5 |
| **H** | Soybean | Large | 2.5 |
| **I** | Cowpea, mungbean (green and black gram) | Large | 2.5 |
| **J** | Pigeon pea, lablab | Large | 2.5 |
| | Horse gram | Medium | 5 |
| **N** | Chickpea (desi and kabuli) | Large | 2.5 |
| **P** | Peanut or groundnut | Large | 2.5 |
| **S** | French, yellow, pink, slender, hybrid and birdsfoot serradellas | Medium | 5 |
| **Special Inoculants** | More than 20 Special Inoculants are made for legume species not covered by the Inoculant Groups above. Legumes requiring special inoculants include Biserrula, birdsfoot Lotus, sulla, messina, tedera, Phaseolus beans (common and kidney), stylo, desmanthus, etc. The full list of Special Inoculants can be found in the *Inoculating Legumes: Practice and Science* guide. | | |

## USEFUL RESOURCES:

**Inoculating Legumes: Practice and Science** grdc.com.au/resources-and-publications/all-publications/publications/2022/inoculating-legumes-practice-and-science/

**Inoculating Legumes in Acidic Soils fact sheet** grdc.com.au/inoculating-legumes-in-acidic-soils

**Inoculating legumes – Tips for Optimising Nodulation fact sheet** grdc.com.au/resources-and-publications/all-publications/publications/2020/inoculating-legumes-tips-for-optimising-nodulation

**A Nitrogen Reference Manual for the Southern Cropping Region**
grdc.com.au/a-nitrogen-reference-manual-for-the-southern-cropping-region

**Legumes in acidic soils – Maximising production potential (southern and northern)**
grdc.com.au/legumes-in-acidic-soils

**Inoculating legumes video** youtube.com/watch?v=L0GNZPGcBPU

**Boosting On-Farm Nitrogen Fixation in Pulses podcasts and webinar**
groundcover.grdc.com.au/crops/pulses/pulse-check-on-pulse-crop-nutrition-planning-for-2020

## GROUND COVER DIRECT HOW TO ORDER

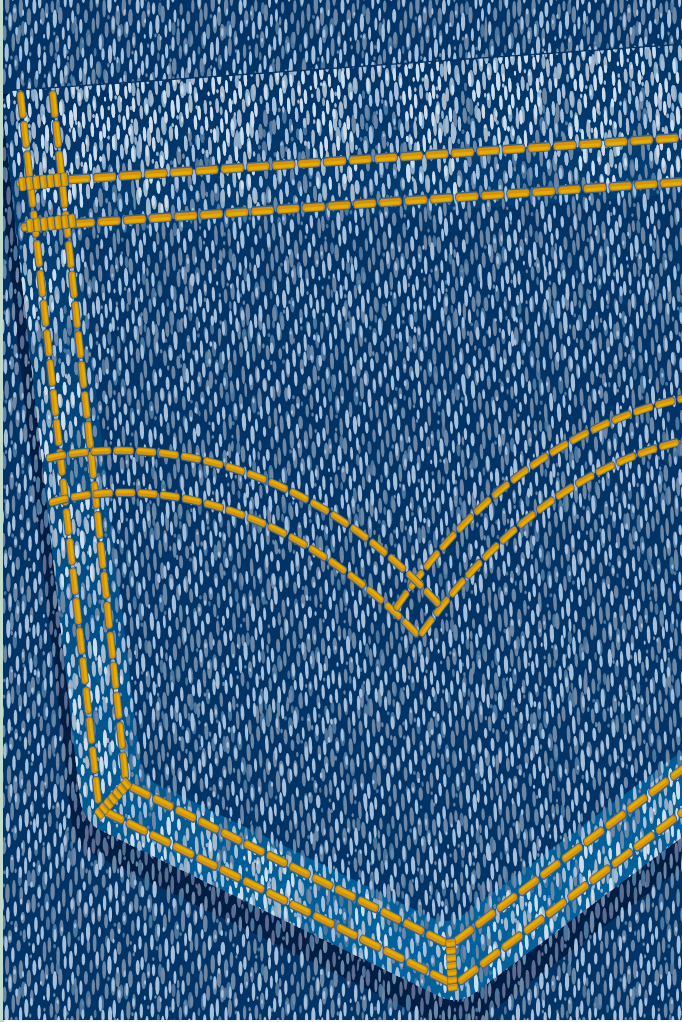
Free phone **1800 11 00 44** | Free fax **1800 00 99 88** | Email **ground-cover-direct@canprint.com.au**
Post Ground Cover direct, PO Box 7456, Canberra MC, ACT 2610

## DNA TEST INFORMATION

pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b

GRDC

**P** Level 4, 4 National Circuit, Barton ACT 2600 | PO Box 5367, Kingston ACT 2604
**T** +61 2 6166 4500 **F** +61 2 6166 4599 **E** grdc@grdc.com.au



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