Checking legume nodulation provides a useful guide to decision making about future inoculation, and indicates whether there is any need to improve inoculation practices.

For inoculated legumes, it is worth checking to see if inoculation has worked well or not. If an inoculated pasture has nodulated poorly, investigate the reason for lack of success.

For uninoculated legumes, it is worth checking if the level of nodulation meets minimum expectations, to help decide whether or not to inoculate in the future.

**Assessing nodulation: what do I need and how do I do it?**

**Equipment:** at least three 10L buckets, a spade, water (tap water from home or shed, or water carried to the paddock; water quality is unimportant).

**When do I sample?**

Ideally 8–12 weeks after sowing, but a few weeks after this is still OK, especially if pasture or crop growth during winter has been slow.

**Taking samples**

1. Collect the root systems (the top 15–20cm of soil) of about 30 plants per paddock, about 10 plants at each of three sample spots using a spade. Put each 10-plant sample in a separate bucket (see sampling pattern diagram, Figure 1). Start sampling 20m from the edge of the crop to avoid headlands. Try to bring soil along and keep the root systems intact. Take particular care in heavy clay soils, where legume nodules can easily break off from the roots. In heavy soils it is best to take samples when soils are moist to aid in collection of roots and nodules.

2. Add plenty of water to each bucket and allow to soak for up to 30 minutes to make the washing process easier. Carefully wash the soil off the roots and rinse to remove remaining soil.

3. Lay the plants out on the back of the ute or on the ground and score each 10-plant sample for ‘% plants adequately nodulated’ (see next step for guidance on this process) and work out the average of the three scores.

**Overall health:** Checking for effective nodulation can also provide an opportunity to identify any other factors that may be limiting production, such as soil constraints, herbicide damage or the presence of soil-borne pests or diseases.

**Assessing nodulation: how do I score it?**

Score each root sample according the presence, pattern and appearance of the nodules.

Nodulation can be affected by a range of management and environmental factors.

Where there is some soil nitrogen, it is possible for pastures to look reasonable, but have few nodules and fix little nitrogen. In these instances, because there are no obvious above-ground symptoms, checking nodulation can provide a useful guide to understanding pasture performance.

Also, while checking the root systems, general root health can be assessed — look for any disease or herbicide damage (both factors that can lead to poor nodulation). For example, depending on location, season and crop rotation or paddock history, there might be a lot of ‘spear tips’ and ‘cut-off’, shortened roots caused by rhizoctonia, or symptoms of other soil-borne diseases.

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Nodulation can be affected by a range of management and environmental factors.
If an inoculated pasture plant doesn’t have many nodules around the crown this suggests inoculation may not have been prompt or successful. Such plants may still have nodules spread around on the lateral roots, if some of the applied rhizobia survived or the correct rhizobia were present in the soil from a previous legume pasture. These pastures may show early signs of nitrogen (N) deficiency, but can recover as the nodules on lateral roots begin to function in fixing nitrogen.

What if nodulation is poor?

Consider taking follow-up samples (single 10-plant samples rather than triple) in other parts of the paddock, as nodulation may be variable. Factors that can lead to nodulation failure or poor nodulation include:

- not inoculating in a paddock where that legume (or a legume in the same inoculation group) has not been previously grown;
- adverse soil conditions, such as very low pH or sowing into dry soil, especially if it is a first time legume pasture (not recommended unless higher rates of inoculant are used);
- poor storage conditions of the inoculant or inoculated seed (see handbooks for storage conditions); using the incorrect inoculant type, where the inoculant group/strain of rhizobia is not compatible with the legume sown;
- high soil nitrate levels due to adding a high a rate of nitrogen fertiliser or from rapid mineralisation of previous crop or pasture residues;
- insufficient rate of inoculant application (doubling the rate of inoculant can be helpful when a legume is grown in a paddock for the first time);
- use of saline bore water or chlorinated water to prepare peat-based or freeze-dried inoculant (advisable to use rainwater or other clean potable water);
- mixing inoculant with fertiliser (especially acidic fertiliser), trace elements or pesticides;
- herbicide damage, either in-crop or from residues (especially SU herbicide residues on alkaline soils); or
- serious root disease (through reduction in root system size and health).

Nodulation failure is extremely difficult to remedy, except by adding nitrogen. Application of nitrogen fertiliser during the growing season may partly recover the pasture over the longer term, but seasonal production is still likely to be less than that possible with adequate nodulation. Nitrogen fixation will be low or absent, which means the nitrogen benefit of growing the legume is lost.

How much nitrogen is actually fixed?

If a legume has no nodules, then it cannot fix nitrogen from the air into ‘fertiliser’ for the plant. If a legume is well nodulated and the nodules are pink (active), this plant is likely to be fixing nitrogen when conditions (soil moisture etc) are suitable.

The actual amount of nitrogen fixed can only be determined by analysing leaf samples, which is time-consuming and costly.

A practical first step to optimising legume nitrogen fixation is to ensure adequate nodulation is occurring. Pay careful attention to the list of factors that can cause poor nodulation. After these have been taken care of, actual amount of nitrogen fixed depends on biomass production; i.e. suitable seasonal conditions and effective pasture management (temperature, soil moisture, nutrition, disease and weed control).

For further information, please refer to publications found at http://www.agwine.adelaide.edu.au/research/farming/legumes-nitrogen/legume-inoculation/ or contact Dr Maarten Ryder, maarten.ryder@adelaide.edu.au

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