Soil health

Legume nodulation

Legumes fix nitrogen via rhizobia in root nodules, boosting plant growth and soil health. Successful nodulation depends on soil conditions and nitrogen levels.

Legumes are important plants within agricultural systems, either in the form of medics and clovers in pastures, or peas, vetch, lentils, beans or lupins in cropping.

Legumes form symbiotic relationships with rhizobia bacteria in nodules on their roots. Rhizobia are soil-dwelling bacteria, with different strains required for each legume species. They infect the roots of the growing plants during seed germination and multiply rapidly to create root nodules. The rhizobia use the host plant for water, nutrients and energy. In exchange, the rhizobia convert nitrogen gas from the air into a form usable by plants, which the plant uses for growth. This process is known as nitrogen fixation. The plant available nitrogen can also be transferred to other non-legume pasture plants or stored in the soil for subsequent crops.

The presence of nodules on the plants is an indication of nitrogen fixation occurring. Having a high number of nodules is favourable as it demonstrates that the plant is healthy, actively fixing nitrogen, producing nitrogen for the soil and will produce high levels of dry matter.

Pink legume nodule sliced in half. Source: MLA

KEY POINTS:

- Legumes form a relationship with rhizobia bacteria in the nodules of the root of the plant. The rhizobia convert nitrogen from the atmosphere into a plant available form.
- The presence of nodules on the roots of a legume plant indicates the level of nitrogen fixation occurring.
- For a legume plant to effectively fix nitrogen it must have a minimum of 20 pink nodules on the root system.
- If plants have poor nodulation, it could be an indication of poor soil pH, the presence of herbicide residue in the soil or unavailable nutrients.

Poor numbers of nodules limit nitrogen fixation which decreases dry matter production and soil nitrogen levels.

Nodulation can be influenced by soil pH, nutrient availability and the use of herbicides. Conversely, if there is an over-supply of N from synthetic fertilisers or soil mineralised nitrogen, rhizobia are less active and nodulation and N fixation become suppressed. Assessing the number of nodules on legumes can be used to determine the health and the amount of nitrogen available to the pasture or crop.

More information

Soil health toolkit

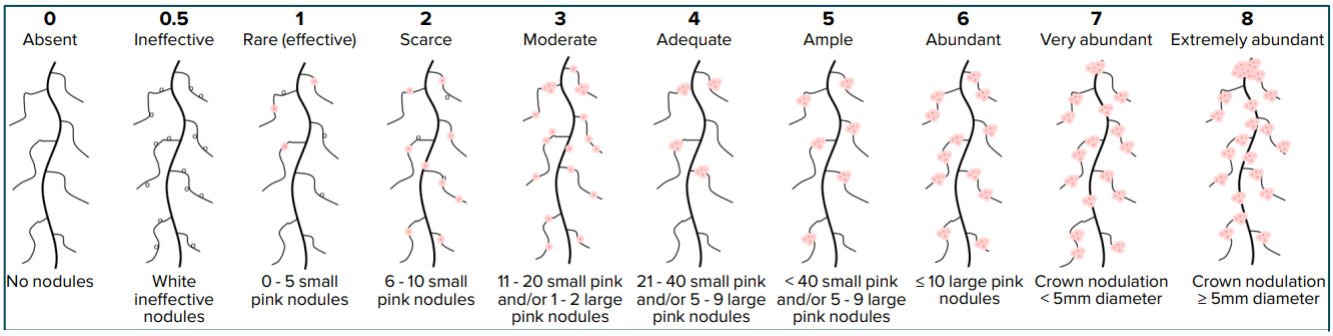

Figure 1: A scoring system used to assess legume nodulation.
Source: Yates RJ, Abaidoo R and Howieson JG (2016) Field experiments with rhizobia. In: Working with rhizobia

Have a go

Nodulation occurs early in the growing season and can be measured once plants are 12 weeks old. This normally occurs in mid to late winter.

Nodules can be found along the roots of the plant. They will appear dark pink to green when cut open. The pink colour indicates the presence of the plant protein necessary to fix nitrogen. If the nodule is white, it is not fixing nitrogen, is poor at fixing nitrogen or contains ineffective rhizobium.

For a legume plant to effectively fix nitrogen it must have minimum of 20 pink nodules on the root system.

Dig up the plants

Choose a representative area of the paddock. Assess a minimum of 15 to 20 plants.

Carefully dig up the plants from the soil by using a shovel. Ensure to dig 30 cm below the plants and remove all the soil, rather than pulling the plants out of the soil which could destroy the nodules.

Carefully wash off the soil in a bucket of water, and gently separate plants to assess individual root systems.

Assess the number and the colour of the nodules using the rating system (*Figure 1*). Placing a white or black background behind the roots highlights the pink colour.

Plants can be classified as either adequate (score 4 to 8) or poor (score 0 to 3) to evaluate nodulation results.

Check your results

If many plants (i.e. >50%) fall into the poor category, further investigation into legume nodulation issues is needed.

Poor nodulation can be a result of:

- **Poor soil pH**: Legumes, and their associated rhizobia tolerate differing levels of soil pH. It is important to understand what the soil pH is and how it affects the plant.
- **Nutrient availability***:* Essential macronutrients like phosphorus, sulphur and potassium, and micronutrients such as molybdenum support legume growth.
- **Use of herbicides***:* Herbicide residue can harm root growth and rhizobia survival. Follow plant-back periods on herbicide labels to minimise impact.
- **Inadequate inoculation***:* Legumes require specific rhizobia to thrive. If legumes have not previously been cultivated in the field, it's possible that the appropriate rhizobia are absent, thus hindering effective nodule formation. In cases where nodules have not developed, it may be necessary to apply the inoculant, or address issues related to an incorrect application.

Addressing these issues can enhance legume performance, nodulation and nitrogen fixation.

References:

How do I assess effective nodulation in legume pastures. Meat & Livestock Australia.

Yates, R.J., Abaidoo, R., and Howieson, J.G. (2016) Field experiments with rhizobia. In: Working with rhizobia, ACIAR.

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