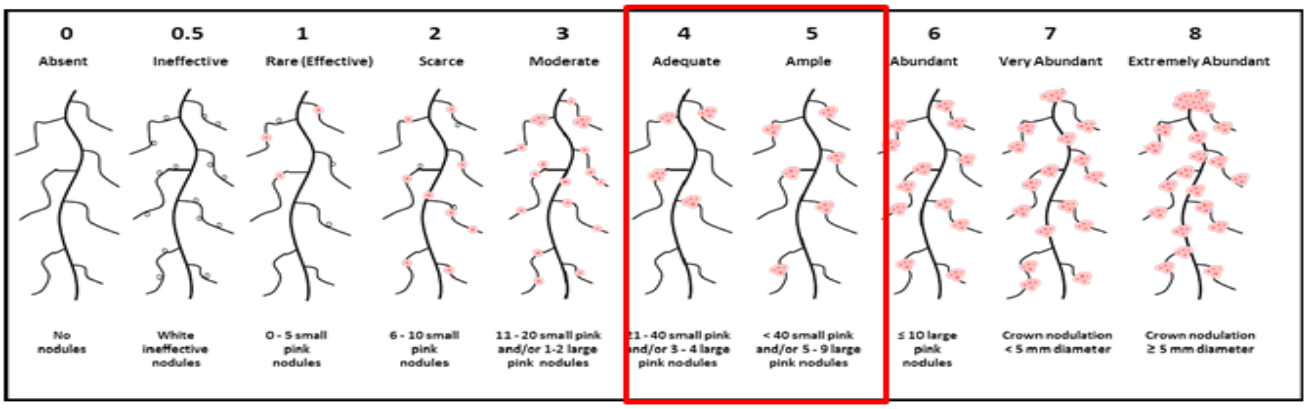
Key messages from the Sub clover health check in the Murray region

What did we want to achieve by conducting the survey;

1. What is the current nodulation status of legumes in the Holbrook Landcare Network region?
2. Is a healthy looking legume plant (above ground) actually fixing nitrogen?
3. Are the current rhizobia strains performing?
4. What factors affects legume production (including nodulation).

Survey methodology

Within a paddock, a representative area of 20 x 20 m was selected where a minimum of 15 legume plants was carefully excavated, washed and scored for nodulation using the 0 – 8 scale (designed by Dr Ron Yates), where a score of 4 is considered adequate.



A composite soil sample was collected along with the clover plant for plant tissue analysis, a botanical composition and the nodules were analysed at MALDI ID for Rhizobium identification.

1. What is the current nodulation status of legumes in the Holbrook Landcare Network region?

The average nodulation score for the survey was 2.9 (range of 1.1 to 5.7). The score is slightly better than the other Local Land Service regions, with the average nodulation score of Central Tablelands 2.3, Central West 1.8, Monaro 2.6, Riverina 2.2 and the irrigation region of the Murray 2.8.

On an individual plant basis, the nodulation score ranged from 0 to 6 and 47% of the plants had a nodulation score of 2 and below which is significantly reduces the amount of nitrogen fixed from the atmosphere. The two paddocks with a nodulation score of 5 were newly sown pasture and it is expected these paddock would score high.

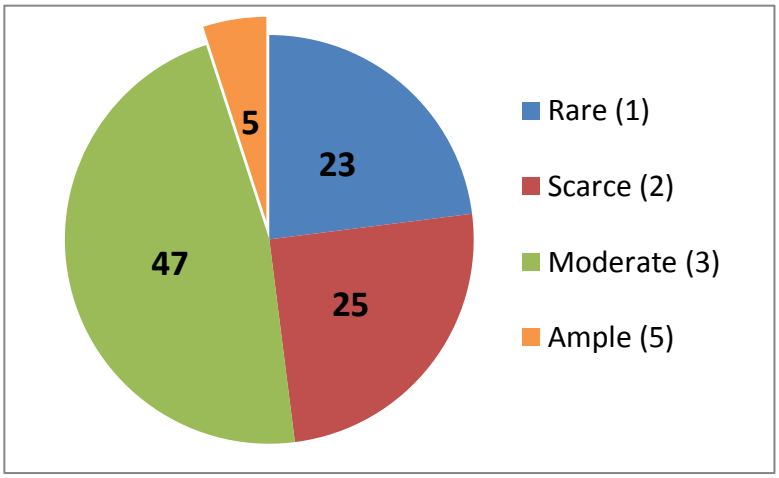


Figure 1: The average nodulation score of the 40 sites within Holbrook Landcare Network

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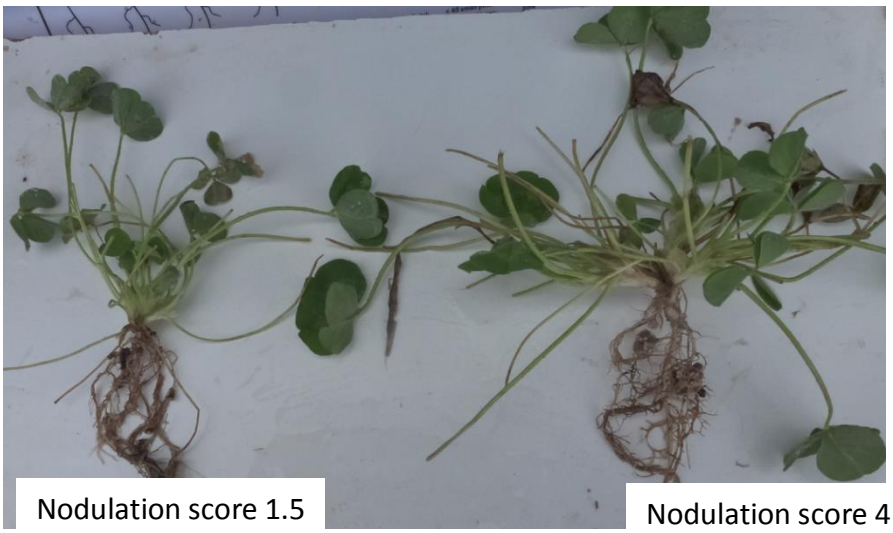
Figure 2: Nodulation score of two plants from same paddock.



Nodulation score 1.5

Nodulation score 4

Sub clover has the ability to fix nitrogen gas from the atmosphere and convert into ammonia which is used by the clover plant for growth. The plants in Figure 2, show the plant with a nodulation score of 1.5 is noticeably smaller compared to the clover with the nodulation score of 4. The general assumption is that a well nodulated sub clover will provide 20 – 30 kg N/t of above-ground dry matter that is produced.

2. Is a healthy looking legume plant (above ground) actually fixing nitrogen?

A healthy looking sub clover above ground does not mean the roots are well nodulated. Below are two paddocks, paddock one had an average nodulation score of 1.1 and paddock two an average nodulation score of 3.8. The low nodulation score did not limit pasture growth. A legume plant not fixing nitrogen from the atmosphere will be using nitrogen from the soil pool. The legume will appear healthy if there is access to sufficient nitrogen in the soil but it will be actually be using soil nitrogen and not building it.

Figure 3: Paddock one (Nodulation score 1.1)

Figure 4: Paddock two (Nodulation score 3.8)

3. Are the current rhizobia strains performing?

In each paddock, four samples were analysed to identify the rhizobia strain present in the nodules.

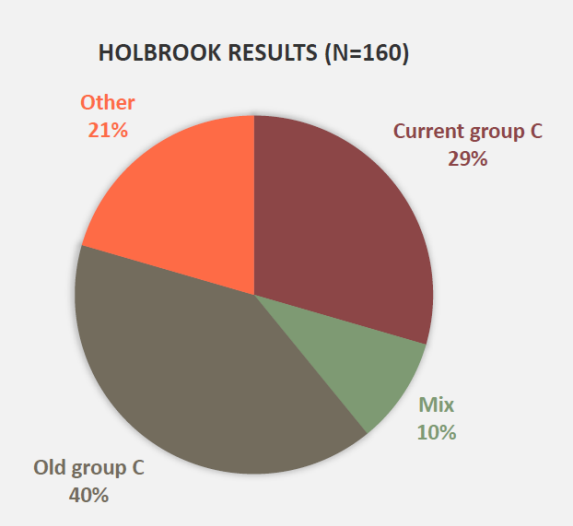


Figure 5: Rhizobia breakdown

Current Group C is the current commercial inoculant (WSM1235) which was released in 2006.

Old Group C consists previously used commercial inoculants.

Mix consists of current and old group C

Other is neither the current or previously used commercial inoculant was detected.

The survey covered newly sown pasture to paddocks were sown 70 years ago with 63 percent of pasture sown since 2006. However, it is concerning that 29 percent of the nodules contain the current Group C rhizobium strain.

4. Factors affecting nodulation.

There are many factors that can potentially affect nodulation and N-fixation including, rhizobia specificity, soil texture, soil pH, soil fertility, certain herbicides, waterlogging, drought and seasonal timing.

Soil acidity and exchangeable aluminium

Soil pH is critical to health and function of the plant and its associated rhizobia. Rhizobium is more sensitive to declining soil pH than the host legume plant. To optimise both plant and rhizobia potential, aim for a soil pH ($CaCl_2$) around 5.5 in the top 10 cm as this is where most of the rhizobia live. The table shows that 18 percent of the 0 – 5 cm samples and 5 percent of the 5 – 10 cm depth are within optimal range for rhizobia.

Soil pH	0 – 5 cm	5 – 10 cm	0 – 10cm
Above 5.5	18%	5%	8%
5.0 – 5.4	30%	15%	30%
Below 5.0	52%	80%	62%

The relative small changes in soil pH is very important. Soil pH is measured on a log scale. This means that a pH of 5 is ten times more acidic than a pH of 6 and a pH of 4 is 100 times more acidic than a pH of 6.

Aluminium becomes available in the soil solution when the pH ($CaCl_2$) falls below 4.8. Aluminium stunts the root system and removes root hairs. The root system of a legume plant sends out signals to rhizobia that results in nodulation. If the root system is damaged by aluminium then this signalling is interrupted and is likely nodulation will be reduced. High quantities of aluminium in the soil solution can be harmful to rhizobia.

Soil pH can be address on pasture to depth with adequate rates of good quality lime, at regular intervals over a number of years. These results might mean that the current liming program is not enough to address soil acidity.

Phosphorus and sulphur

For the plant phosphorus is essential for root growth and photosynthesis. From the perspective of rhizobia, phosphorus is essential for bacterial growth and for the conversion of atmospheric nitrogen to ammonia. The plant

requires sulphur for the formation of chlorophyll, amino acids, protein and enzymes. The rhizobia requires adequate sulphur to ensures greater supply of sugar enabling the population of rhizobia to increase and it is a key component of the enzyme nitrogenase which rhizobia use to convert atmospheric nitrogen to ammonia in the nodule.

Soil phosphorus levels were above critical values in 75 percent of the paddocks, however, 53 percent of paddocks were below the critical value for sulphur. However, the sulphur plant tissue sample indicated only 5 clover pastures were below marginal levels.

Molybdenum

The plant requires molybdenum for the breakdown of nitrates taken up from the soil and molybdenum is a component of the nitrogenase enzyme which is critical for nitrogen fixation. Molybdenum availability decreases with declining soil pH and therefore molybdenum applied to acidic soils may not be available to the plant. Half the clover samples were deficient in molybdenum.

Molybdenum can be applied as a coating on the fertiliser granule or via a spray. If applied by the fertiliser granule it is only required every five to six years. However, if using the spray, an annual application may be required as it is taken up by the plant as the spray is not reaching the soil surface. This might mean the rhizobia might not be receiving adequate molybdenum required to for nitrogen fixation.

It needs to be stressed that this survey is a first for the district and therefore a snapshot of the nodulation status for the spring of 2017. For a better understanding of nolulation of the clover plant and the impacts of climatic conditions, a regular monitoring program is required.

Follow is a summary of the other regions in NSW.

LLS region	Number paddocks	Average nodulation score (0 – 8)	pH($CaCl_2$) (0 – 10cm)	Al (% CEC)	P (Colwell) (mg/kg)	S (KCl-40) (mg/kg)
Central Tablelands **Pdks less than critical %	30	2.3 (0.8 – 4.3) 93	5.0 (4.4 – 5.7) 87	3.1 (0.12 – 12) 80	30 (6 -133) 63	7.1 (2.7 – 14.6) 70
Central West Pdks less than critical %	60	1.8 (0 – 6.7) 90	5.2 (4.3 – 7.6) 73	1.9 (0 – 10) 90	29 (8 – 150) 41	5.0 (0 – 18) 95
Monaro Pdks less than critical %	54	2.6 (1.1 – 5.1) 96	5.1 (4.2 – 8.2) 80	4.1 (0 – 29) 81	44 (11 – 120) 43	7.9 (2.0 – 31) 63
Riverina Pdks less than critical %	81	2.2 (0.5 – 4.9) 96	5.2 (4.3 – 6.7) 75	3.5 (0.5 – 24) 80	42 (6 – 170) 37	6.5 (1.0 – 24) 72
Murray (Holbrook) Pdks less than critical %	40	2.9 (1.1 – 5.7) 95	4.8 (4.1 – 6.2) 92	8.4 (0 – 25.9) 55	44 (11 – 122) 25	8.4 (2.9 – 18.2) 53
Murray (Irrigation) Pdks less than critical %	20	2.8 (1 – 5) 85	5.5 (4.3 – 6.5) 35	< 1 (< 1 – 13) 5	63 (25 – 160) 10	9.7 (3.5 – 53) 65

Table 1: Legume nodulation and key soil chemical parameters from a legume nodulation survey across Central Tablelands, Central West, Monaro, Riverina and Murray regions of NSW

** Shows percentage of paddocks with nodulation score < 4.0
pH percentage of sampled paddocks with pH_{Ca} < 5.5
For exchangeable aluminium < 5% of CEC
Colwell P less than critical value based on phosphorus buffering index
Sulphur paddocks less than 8 mg/kg (critical value for clover)