LEGUMES AND NITROGEN FIXATION —SOUTH AUSTRALIA

Key points

- Legumes can fix substantial quantities of nitrogen (N) and this can be maximised by ensuring low plant available N in the soil at sowing and inoculating the seed if a paddock has not had a host legume nodulated by the same rhizobia in the last four years.
- Acid soils will require more regular inoculation or liming (except for narrow-leaf lupin).
- The net N benefit from N fixation by legumes is dependent on the balance between atmospheric nitrogen (N_2) fixation and N removed as grain, hay or forage.
- Legume N residues can make an important contribution to N uptake and grain N of following crops.

Background

All plants are able to take up nitrogen from the soil in the form of ammonium (NH_4^+) or nitrate (NO_3^-); together these are known as available N. In addition to taking up available N from the soil, legumes (clovers, medics, peas and beans) are also able to acquire N from the abundant supply in the atmosphere via special soil bacteria (rhizobia) which are housed in nodules on their roots. With fully functioning nodules, legumes can grow in soils that are deficient in available N. These rhizobial 'factories' are subject to variation in establishment and performance and so a supportive environment must be provided to maximise N_2-fixation.

Figure 1: *Good nodulation on faba bean.*

Rhizobia, nodulation, available soil nitrogen and nitrogen fixation

Rhizobia tend to be widespread in soils, however they are not all equally effective. While most are happy to reside in nodules, not all are able to efficiently fix (N_2). To ensure large numbers of efficient rhizobia are present in the legume nodules (figure 1), it is advisable to inoculate legume seed at sowing with the recommended strain of rhizobia if the paddock has not been inoculated with that rhizobia, or has not grown a crop of a suitable host legume for that rhizobia in the last 4 years.

Survival of rhizobia and legume nodulation will be reduced in acid soil (pH <5), except for narrow-leaf lupin. To maximise N_2-fixation in low pH soils, more regular inoculation and/or liming is required.

Where available soil N is low, the amount of N_2 fixed is directly proportional to legume dry matter production (figure 2). If legume crops in any one location have about the same total dry matter, then you would expect them

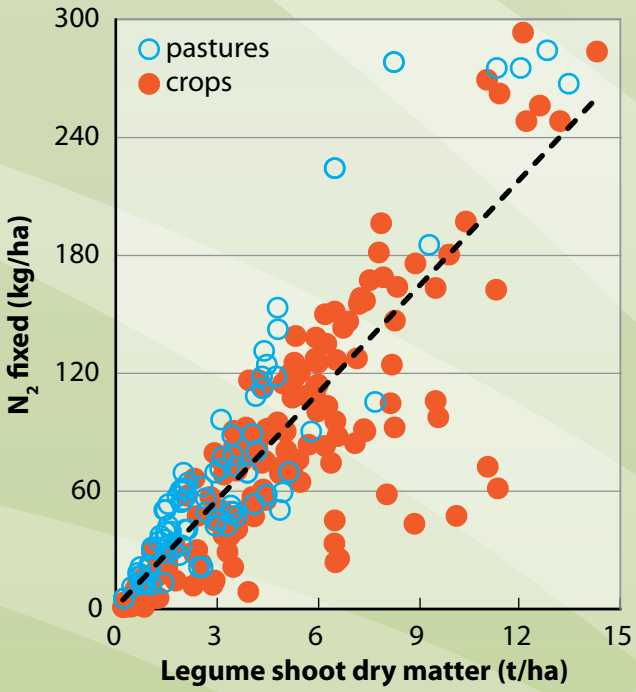

Figure 2: *Relationship between legume shoot dry matter and fixed-N in shoots for crops and pastures in Australia.*

Table 1: *Average amount of fixed N (kg N/ha) in shoots plus roots of legumes per tonne of shoot dry matter (from Unkovich et al. 2010).*

LEGUME SHOOT DRY MATTER (t/ha)	CHICKPEA	FIELD PEA, FABA BEAN	LUPIN	ANNUAL CLOVERS	LUCERNE
1	21	23	23	32	38
4	87	80	80	140	150
8	175	155	155	279	300
12	263	231	231	417	449

to fix about the same amount of N (table 1), while equally productive pastures tend to fix more N.

Moderate available soil N (>35 kg/ha) will reduce crop legume N_2-fixation by a similar amount. In pastures with companion grasses this mineral N will be taken up by the non-legume component and N_2-fixation will not be suppressed. Approximate amounts of N_2 fixed by crops and pastures can be gauged from figure 2, although this does not include root N, which might contribute another 30%.

How much N do legumes contribute to following crops?

At maturity 30–40% of the N in legume crops is in the seeds, which are typically 25–30% protein. When this grain is harvested, much of the N that has been fixed will be exported off of the property. However, the N remaining in the shoot and root residues means that legumes usually make a positive contribution to soil N reserves in southern Australia.

‚A healthy and productive field pea crop could fix up to 200 kg N/ha

Further reading and references

Drew E et al. (2012) *Inoculating legumes: a practical guide*, GRDC, Canberra. (online)

Unkovich M, Baldock J, Peoples M (2010) Prospects and problems of simple linear models for estimating symbiotic N_2 fixation by crop and pasture legumes. *Plant & Soil* **329**: 75-89.

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