A new approach for quantifying the role of legume nitrogen in crop rotation.

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Abstract

Significant amounts of N_2 fixed by legumes are incorporated into the soil as fallen leaves and stems, but nitrogen (N) will also be contributed by roots, nodules and root exudates. Generally, large proportion of the N accumulated during the growth of crop legumes is removed with the harvested seed, it is commonly concluded that the net return of fixed N to the soil is likely to be small. When the amounts of N_2 fixed by legumes have been compared with the N removed in seed, most calculations have relied totally on above-ground measures of fixed N. However, recent applications of the ^{15}N-shoot labelling techniques to field grown crops suggest that the below-ground pool of legume N (nodules, roots and their exudates) may represent between 24% (fababean) and 76% (chickpea) of the total plant N. In the past, the values of legume rotations have been greatly underestimated as the root contribution of N has previously been ignored.

Media summary

Applications of the 15N-shoot labelling techniques to field grown crops suggest that the below-ground pole of legume N may represent 24% and 76% of the total plant N in fababean and chick pea, respectively.

Key Words

Legume, Nitrogen fixation, the 15N-labelling.

Introduction

Nitrogen balances of legume phases of crop and crop-pasture rotations either ignore or underestimate the below-ground fraction. Nitrogen contained in intact and partly decomposed roots and nodules of legumes and in the soil as deposited organic and inorganic materials may represent the largest source of N contributing to soil N fertility. Calculations of N_2 fixed by legumes are normally based solely upon shoot-based measures of fixed N, with the below-ground contribution of N ignored. This has major implications for our understanding of the potential role of pulses in the N economies of cropping systems and may adversely affect our management of those systems. The objective of this study was to adapt a ^{15}N shoot labelling technique to quantify the below-ground fraction of legume N in the filed.

Methods

A field experiment (commenced in May 1997) with chickpea and faba bean was conducted at the Breeza long-term experimental site in the northern New South Wales, Australia. At the seedling stage, 4 metal microplot frames measuring 0.5 m x 0.64 m were placed in the ground to a depth of about 30 cm in each of 8 plots for the ^{15}N study. Each microplot contained either 7 (chickpea) or 8 (faba bean) plants. All the plants within the microplot were fed with 0.2 ml of 0.5% ^{15}N urea (99% atom% ^{15}N) on five occasions during vegetative and early reproductive growth phases. The microplots were harvested just prior to physiological maturity. Shoots, intact roots and all soil to 25 cm depth (8 soil corse of 25-45 cm) were recovered for dry matter, %N and ^{15}N analyses.

Results

The ^{15}N and N contents of shoots, recovered roots and soil collected at around the time of peak biomass were used to determine the amount of crop N partitioned above- and below-ground. The ^{15}N enrichment of all plant and soil samples was measurably greater than natural abundance. Recoveries of ^{15}N were greater than 80% of the ^{15}N supplied to the plant shoots during growth. Calculations using the ^{15}N excess of the recovered roots and the ^{15}N enrichment of soil suggested that 24 and 76% of total crop N was associated with the roots of faba bean and chickpea, respectively (Table 1). The below-ground value for faba bean (equivalent to 41 kg N/ha) lay similar to previous measurements using ^{15}N-based techniques (Russell and Fillery 1996; Rochester et al. 1998). However, the value derived for chickpea roots seemed excessively high because of very low ^{15}N content in the recovered roots, and a very high in the 0-25 cm soil component (Table 1).

Table 1. Estimates of below-ground plant N (BGN) for field-grown faba bean and chickpea (all data are expressed per 0.32 square meter microplot).

Species	Shoot	Recovered root		BGN in soil		Total BGN	
	gN	gN	Mg^{15}N/gN	mg ^{15}N	gN[a]	gN[b]	% crop N[c]
Faba bean	5.42	0.14	2.4	3.77	1.57	1.71	24 ? 3.4
Chickpea	2.18	0.16	1.2	8.03	6.69	6.85	76 ? 1.5

[a] $BGN_{soil} = (^{15}N_{soil} / ^{15}N_{RR} /g)$; [b] $BGN_{total} = N_{RR} + BGN_{soil}$
[c] Total BGN as % crop N = 100 x (total BGN)/(shoot N + total BGN). Data indicating mean ? SE

The shoot-labelling approach used to estimate below-ground N is based on two assumptions, that:

- All ^{15}N excess detected in soil originated from ^{15}N enriched material.
- The relationship between mg ^{15}Nexcess/gram root N of the recovered root sample was representative of the N concentration and ^{15}N enrichment of all root derived N present in soil.

Conclusion

Shoot-labelling techniques have been adapted for quantifying below-ground N in legumes. The results suggested that 24% and 76% of total legume N was associated with, or derived from roots in faba bean and chick pea, respectively.

References

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