The contribution of grass and clover root turnover to N leaching

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Abstract: Sources of inorganic and organic N leaching from grass-clover mixtures at field sites in Denmark, Germany and Iceland were investigated. Grass or clover was labelled with ^{15}N-urea four times (autumn 2007, spring, summer and autumn 2008) prior to the leaching season in autumn and winter 2008. Soil water was sampled at 30 cm depth and analyzed for ^{15}N-enrichment of dissolved inorganic N (DIN) and dissolved organic N (DON). Most ^{15}N was recovered in DON for both labelled grass and clover at all sites. At the Danish site, grass and clover contributed more to the DON pool than the DIN whereas the opposite was observed at the German and Icelandic sites. The results show that both clover and grass contribute directly to N leaching from the root zone in mixtures, and that clover contribution is higher than grass. Furthermore, the present study indicates that roots active in the growth season prior to the drainage period contribute more to N leaching than roots active in the growth season the previous year, which is consistent with estimates of root longevity at the three sites.

Keywords: DIN, DON, clover, grass, leaching

Introduction: Leaching of nitrogen (N) from agricultural land largely depends on soil N status, crop choice, management practice, and climatic conditions. Legumes like clover constitute the main N input in many low-input agricultural systems (Lampkin 2002), supplying both companion and following crops with this often limiting nutrient (Høgh-Jensen 2006). There is increasing interest in the sources of N being leached from grass-clover swards. DON has been identified as an important proportion of the total N loss (Jones et al. 2004). The environmental impact of dissolved inorganic N (DIN) leaching is well described, but the fate of DON is not well understood. Characterisation of DON composition and sources are essential when evaluating management strategies to reduce the environmental impact of agricultural systems. The aim of the present study was i) to identify the sources of DON and DIN leaching from grass-clover swards under different soil, climatic and management regimes, ii) to determine the distribution of N between DON and DIN, and iii) to relate these finding to grass and clover root turnover.

Materials and methods: Similar field experiments were conducted at three locations on (1) a sandy soil (7.7% clay, 1.6% organic carbon (C)) at Foulumgård Experimental Station, Viborg, Denmark, (2) a more clayey soil (10.1% clay, 1.3% organic C) at Lindhof Experimental Station, Kiel, Germany, and (3) an organic soil (18% clay, 8.4% organic C) at Korpa Experimental Station, Reykjavik, Iceland. Grass or clover were leaf-labelled with ^{15}N-urea (Høgh-Jensen and Schjoering, 2000) within small PVC cylinders (ø 10 cm), inserted 2cm into the soil in existing grass-clover swards. Leaf-labelling was done in new plots four times from autumn 2007 to autumn 2008. Soil water was sampled using Teflon suction cups installed at 30 cm depth beneath the PVC cylinders in winter 2008, to determine the total N concentration and the ^{15}N-enrichment of the DIN and total dissolved N (TDN) (Rasmussen *et al.,* 2008). In early spring 2009, root samples were taken from the labelled species in the PVC cylinders to measure the ^{15}N-enrichment.

Results and discussion

At all three locations both leaf-labelled grass and clover were sources of ^{15}N in soil water samples. DON constituted the largest part of the total N sampled with the exception of one sampling at the Danish site in February (Table 1). The proportion of DON is higher than found in previous studies in cultivated soil with deeper sampling (1m) (Vinther *et al.,* 2006), which can be explained by the sampling of soil water just beneath the ploughed layer.

The presence of ^{15}N in DON showed a marked difference between the sites (Table 1). In Denmark, the proportion of ^{15}N-DON of total ^{15}N was always higher than the proportion of DON of total N. This strongly indicates that labelled plants contributed more to the DON pool than to the DIN pool in the sampled soil water. The opposite was true for the field sites in Germany and Iceland where the proportion of ^{15}N-DON of total ^{15}N was less than or equal to the proportion of DON of total N, i.e. labelled plants contributed more to the DIN pool, and thus more DON originated from other sources. From the present experiment we cannot deduce the determining factor of this difference (e.g. climate or soil conditions), but we suggest that soil texture could play a role in the retention and mobility of DON in the upper soil layers with less retention in sandy soil compared to clayey and organic soils.

Table 1. DON proportion of total N and ^{15}N-DON of total-^{15}N in soil water samples from Denmark, Germany, and Iceland.

Site	Sampling date	DON of total N	^{15}N-DON of total ^{15}N	Replicates
Denmark	Dec. 2008	0.79 ± 0.01	0.86 ± 0.01	15
	Feb. 2009	0.34 ± 0.01	0.63 ± 0.01	16
	April 2009	0.70 ± 0.01	0.81 ± 0.01	17
Germany	Dec. 2008	0.82 ± 0.01	0.82 ± 0.01	14
	Feb. 2009	0.81 ± 0.01	0.71 ± 0.01	13
	April 2009	0.94 ± 0.00	0.86 ± 0.01	6
Iceland	Jan. 2009	0.96 ± 0.00	0.90 ± 0.00	6

The presence of ^{15}N in both DIN and DON was related to the time since leaf-labelling. In the example given in Figure 1, it can be seen that ^{15}N in DIN for both labelled grass and clover decreased with time since labelling (lowest for the plots labelled 14 months before soil water sampling). The opposite trends were found for DON with ^{15}N contents increasing with time since labelling, except for labelled clover in the plots labelled 14 months before soil water sampling. Comparing across field sites and between sampling times at the individual field sites gives a less clear picture of the contribution of labelled grass and clover to ^{15}N in DIN and DON. However, it is clear that grass and clover labelled in the growth season prior to soil water sampling contributed in all cases to both DIN and DON.

The ^{15}N-enrichment remaining in the roots from labelled grass or clover sampled after the leaching season in Denmark and Germany showed that clover roots had survived less than a year, whereas grass roots seemed to survive longer. In Iceland, the trend, although less clear, was that both clover and grass roots survived longer compared to Denmark and Germany.

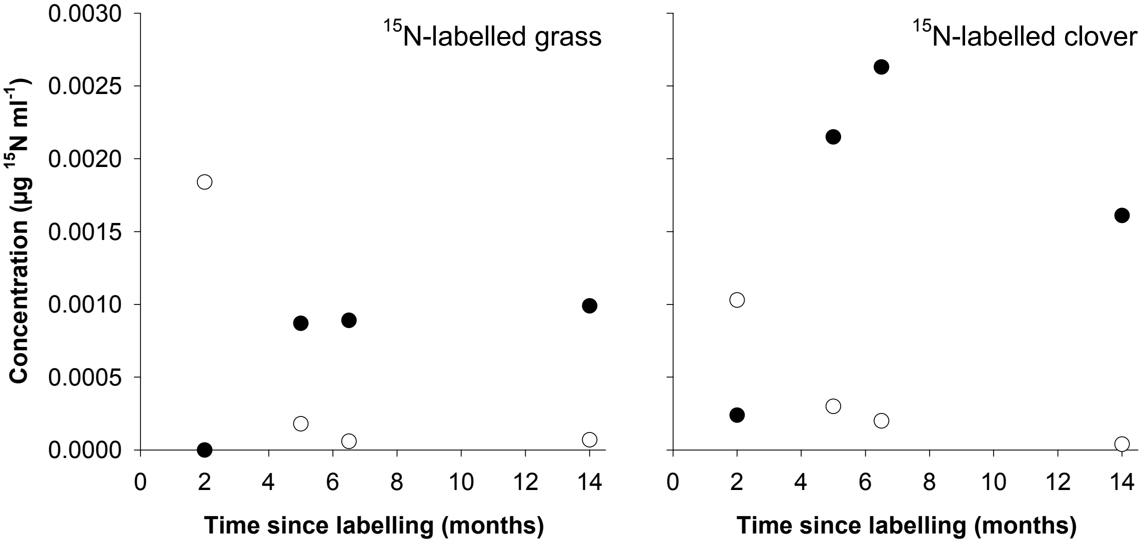

Figure 1. ^{15}N in DIN (○) and DON (●) from leaf-labelled grass and clover at the December 2008 soil water sampling in Denmark as related to the time since labelling. The number of replicates on each data point varies from 1 to 3.

Conclusions: The present experiment showed a direct contribution from both grass and clover roots to leaching of DIN and DON at 30 cm. DON was the dominant N form in all sites and the presence of ^{15}N in this pool was consistent with the presence of ^{15}N in the roots after the leaching season.

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