Below ground C and N transformation processes in perennial grass-clover mixtures with impact on the farming system and the environment

Name:	Jim Rasmussen
University:	The Royal Veterinary and Agricultural University
Department:	Department of Agricultural Sciences
Supervisor:	Henning Høgh-Jensen (KVL) / Jørgen Eriksen (DIAS) / Erik Steen Jensen (RISØ)
Timescale:	Expect to finish March 2007
E-mail/phone:	jjr@kvl.dk / 3528 3520
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Background

The C and N dynamics in perennial grass-clover mixtures are not fully understood although such mixtures dominate temperate grassland. The co-existence of clover and grass involves both competition for and transfer of nutrients between the species. The nutrients may originate from leaky root systems, from a rapid turnover of the fine root systems, or from degradation of more stabile organic material. A better understanding of the processes involved in the C and N dynamics, especially the role of organicly bound C and N, will form the basis for better modeling of grass-clover mixtures and thereby optimizing the utilization of the nutrients which benefits both the farmer and the environment.

Objective

The aim of the study is investigate the C and N dynamics in grass-clover mixtures with special attention to

- determine the origin of DOC and DON in grass-clover mixtures
- determine the composition of DOC and DON from the species
- investigate the transfer of C and N between grass and clover

Status - 2004

In 2004 a field experiment was conducted with the aim to investigate the origin of C and N from both grass and clover related to the short term dynamics in the roots system deposition and turnover. In a second year grass-clover ley mezotrons were installed to depths of 20, 40 and 60 cm. Underneath the mezotrons suction cups were installed in order to collect porewater from the root zone. Grass or clover in the mezotrons was labeled using leaf labeling with ^{15}N- and ^{14}C urea. During the experimental period of app. 3 months percolation porewater from the root zone was collected, and the canopy was harvested at three times occations. At the end of the experimental period the mezotrons were excavated and divided into soil and plant compartments. In order to model the water transport in the mezotrons bromide was added before the leaf labeling, and in order to have a surplus of porewater the mezotrons was irrigated at regular intervals.

The status in October 2004 was that only few analyses of the collected samples had been carried out at that time.

Progress - 2005

In 2005 a new field experiment has been undertaken and further analysis of the samples from the 2004 experiment has been conducted.

Regarding the 2004 experiment all samples has been analysed except the measurement of ^{15}N labelled organic and inorganic pools in the percolating porewater; these measurements will be conducted when the method for analyses has finished.

From the results obtained so far, it seems that it will be possible to determine the origin of DOM in a grass-clover mixture when the data on ^{15}N in the leachates becomes available. The data from the ^{14}C-labelling show that leaching of ^{14}C occurs immediately after the tracer has entered the plants and that the majority of the leached ^{14}C is in the form of $^{14}CO_2$. In general grass show a higher leaching of ^{14}C, but in a few cases labelled clover results in higher ^{14}C peaks, but in all cases the amount of ^{14}C leached is very low. The detection of ^{14}C decreased with depth and only from labelled grass ^{14}C was detected at the depth of 60 cm. Based on these results it is concluded that leached DOC beneath the rootzone is not likely to originate from depositions from the living root system.

Analysis of plant material show that ^{14}C and in particular ^{15}N are transferred between the species, with the highest transfer of N occurring from clover to grass and the highest transfer of ^{14}C occurring from grass to clover. The distribution of ^{14}C and N derived from the roots in the upper 20 cm in the field mezotrons shows that in general ^{14}C in roots and soil comes from grass, while N comes from clover. No ^{14}C is found beneath the plough layer when clover is labelled whereas a small fraction is found when grass is the labelled species. The deposition of N occurs mainly in the plough layer for both grass and clover.

The results from this dual-labelling study with ^{14}C and ^{15}N confirms the hypothesis that clover acts as the N donor and grass as the C donor in grass-clover mixtures. Simultaneously to contributing to the co-existing specie, large amounts of carbon and nitrogen are deposited in the soil. It is therefore deduced that large fluxes of both carbon and nitrogen is occurring below grass-clover sods.

In spring 2005 a field experiment was undertaken in order to study the long term C and N dynamics in grass clover mixtures. The aim of the 2005-2006 studies is to investigate the fate of root and leaf material from grass and clover respectively during two growth seasons. Dual-labelled (^{14}C and ^{15}N) plant material was incubated in field mezotrons inserted in a first year grass clover ley. In the growth seasons of 2005 and 2006 leaf material is harvested and analysed for content of ^{14}C and ^{15}N to investigate the possible uptake of C and N from degrading plant material. In May and September 2005 a number of mezotrons were excavated and incubated plant material, soil and roots were separated. Also in April and September 2006 mezotrons will be excavated to determine the distribution of the two tracers in the soil and roots. During the winter period of 2005 percolating pore water from the mezotrons will be sampled using Teflon suction cups. The content of ^{14}C and ^{15}N in the pore water will be analysed and if possible separated in organic and inorganic pools.

Plans - 2006

The plans for 2006 are to finish the last analyses from the 2004 experiment and complete the publication of these data. Regarding the field experiment initiated in 2005 further samples have to be taken, and analyses of all the samples from the 2005-2006 field experiment have to be carried out.

Publications

Rasmussen, Jim and Høgh-Jensen, Henning (2004) Origin and composition of Dissolved Organic C and N from grass-clover mixtures. Poster presented at Cost Action 627 - Carbon Storage in European grasslands, Ghent, Belgium, June 3-6 2004