Production of N_2O in grass-clover pastures

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Background

Grass-clover pastures are an important component in organic dairy farming systems, and are typically grazed for a significant part of the year. Nitrogen depositions from grazing cattle's excreta are at risk of being lost to the atmosphere or lost via leaching. In addition, the grass-clover pastures are expected to have a high level of nitrogen in the root zone due to the fixation of atmospheric dinitrogen (N_2). Both factors could contribute to increased emissions of nitrous oxide (N_2O). Nitrous oxide is a strong greenhouse gas with agricultural soils as a significant source. Thus far, however, there have only been a few accurate estimates of total N_2O emissions from grassland livestock production systems, and understanding of the factors controlling N_2O emissions remains unsatisfactory.

Objective

The aim of the Ph.D.-project is to increase the knowledge of the biological and physical-chemical mechanisms, which control the production of N_2O in grazed grass-clover pastures. Such knowledge is a necessity for a complete environmental evaluation of organic farming practices. The Ph.D.-project consists of three different experiments, which have the following objectives:

Experiment 1

- develop a method to measure N_2 fixation and N_2O production in pot experiments using $^{15}N_2$-labelling technique
- assess the contribution of recently fixed N_2 as a source of N_2O and the translocation of N from clover to companion grass

Experiment 2

- identify which of the two microbial processes, nitrification or denitrification, is the main responsible for the production of N_2O
- study how nitrification and denitrification are influenced by urine deposition

Experiment 3

- investigate the connection between N_2O production and carbon mineralisation in urine spots

Progress - 2003

At present, all three experiments have been conducted. Experiment 1 ended in December 2002. Experiment 3 took place in Spring 2003 during a 3 months stay at Institut National de la Recherche Agronomique (INRA), Clermont-Ferrand, France. Briefly, the experimental work was conducted in an experimental facility, which has been established by the research group of Dr. Jean-François Soussana. In the experimental facility, monoliths from permanent grasslands are continuously ^{13}C-labelled using air depleted in $^{13}CO_2$. To simulate grazing, the vegetation was cut twice, *viz.* 22 April and 9 June 2003. After 14 and 7 days respectively, urine was added to half of the monoliths. The experimental work was carried out during two 12-days periods in relation to the simulated grazing events. Below-ground N_2O

and $^{13}CO_2$ productions in the monoliths were measured by a static chamber method using small chambers consisting of 3 and 5-cm diameter pipes, which were installed between the plants.

Experiment 2 took place in August/September 2003 in an organic grass-clover ley at Højbakkegård, KVL Taastrup. Briefly, the loss of N_2O from nitrification and denitrification were determined using a ^{15}N-tracing technique. In 30-cm diameter cylinders installed in the field, either soil ammonium or soil nitrate was labeled with ^{15}N. After a 2.5-hours incubation period, a gas sample was taken for analysis of atom% ^{15}N of emitted N_2O. The rate of total N_2O emission from nitrification and denitrification (E) is determined by four parameters forming the following equation:

$$E = N \bullet F_N + D \bullet F_D$$

where N and D are the rate of nitrification and denitrification, respectively, F_N is N_2O-N produced per NH_4^+ oxidised in nitrification and F_D is N_2O-N produced per NO_3^- reduced in denitrification. It is well known that grazing cattle's urine deposition locally gives rise to a high N_2O emission. Using various nitrogen isotope techniques and determination of denitrification by acetylene-inhibition, it was examined how deposition of synthetic urine affects each of the four parameters N, D, F_N and F_D. This was compared with the specific effect of inorganic nitrogen by adding ammonium chloride-N in the same quantity as the nitrogen content of the urine treatment.

So fare, chemical analyses have been conducted on gas samples from the 3 experiments as well as on plant and soil samples from experiment 1. A poster containing preliminary results of experiment 1 was presented at 12th N Workshop 'Controlling N Flows and Losses', Exeter, UK, 21-24 September 2003.

The activities in 2003 also involved participation in the Research School for Organic Agriculture and Food Systems (SOAR), which included hosting the half-yearly seminar 28-29 November 2002. Furthermore, the requirements of KVL concerning amount of passed Ph.D. courses have been fulfilled.

Plans - 2004

Midterm seminar will be held 22 October 2003 at Højbakkegård, KVL Taastrup. Analyses of soil extracts from the 3 experiments still remain and will be carried out shortly. Data from the 3 experiments will be analysed and paper drafts will be written. This includes scientific papers as well as two popular science papers on experiment 1 for 'Økologisk Jordbrug' and 'DARCOF news'.