From N_2 fixation to N_2O emission in a grass-clover pasture[1)]

Mette Thyme and Per Ambus

Plant Research Department, Risø National Laboratory,
P.O. Box 49, DK-4000 Roskilde

Introduction

In organic dairy farming, a major N input to the plant-soil system comes from biological N_2 fixation by pasture legumes, but knowledge is sparse on how much of the fixed N_2 is lost from the pastures as N_2O. Nitrifying and denitrifying bacteria are the main contributors to the N_2O production in soils.

Currently, no contribution from biological N_2 fixation in legume pastures is included in the national N_2O inventories, partly because of uncertainties in quantifying the N_2 fixation in the pastures (Mosier et al., 1998). According to the guidelines issued by The Intergovernmental Panel on Climate Change (IPCC), inventories for

N_2O emissions from agricultural soils should be based on the assumption that 1.25 % of added N is emitted as N_2O (IPCC, 1997). The standard N_2O emission factor of 1.25 % could be considerably unrepresentative for biologically fixed N_2. Firstly, only a part of the fixed N is mineralised during the lifetime of the crop. Secondly, the release of inorganic N into the soil occurs slowly.

A $^{15}N_2$-tracer-experiment was initiated on grass-clover grown in pots. The aim was to assess:

- the contribution of recently fixed N_2 as a source of N_2O
- the translocation of N from clover to companion grass

Methods

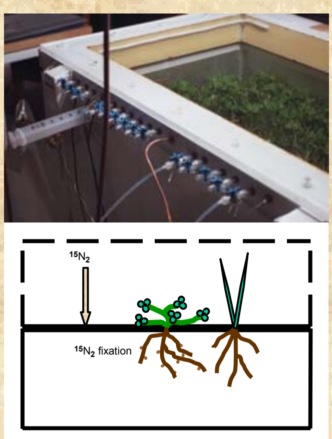

Fig. 1. The growth cabinet and labelling approach.

- A minimum-volume gastight growth cabinet was constructed by rebuilding a chest freezer (Fig. 1).
- $^{15}N_2$ was introduced into both the above- and below-ground atmosphere to trace the symbiotic fixation.
- Three 14 days incubations were conducted with 4, 6 and 8 months old grass-clover.
- After each labelling event, half of the grass-clover pots were harvested to determine the N_2 fixation.
- Emission of $^{15}N_2O$ was measured from the remaining half of the pots over the following seven days, using a static chamber method (Fig. 2).

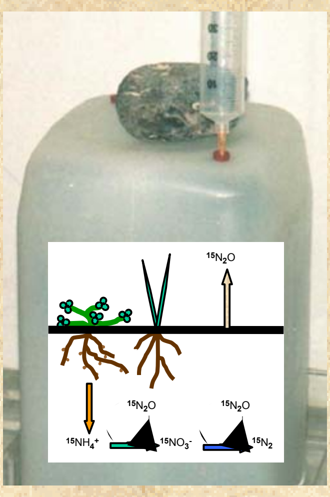

Fig. 2. Static chamber method for measurement of $^{15}N_2O$ emission. Mineralisation Nitrification Denitrification.

Results

- At 4 months, N_2 fixation measured in grass-clover shoots and roots constituted 339 mg N m^{-2} d^{-1} (Fig. 3).
- This is twice to 10 times larger compared to daily average of field measurements (Høgh-Jensen & Schjoerring, 1997; Vinther & Jensen, 2000), probably because of optimal growth conditions.

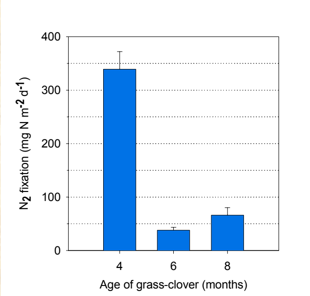

Fig. 3. Symbiotic N_2 fixation measured in grass-clover shoots and roots; n = 4, means ± SE.

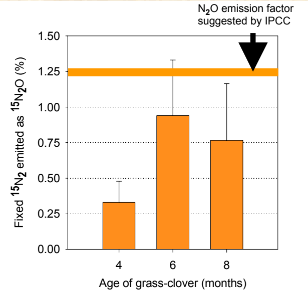

Fig. 4. Fraction of fixed $^{15}N_2$ emitted as $^{15}N_2O$; n = 4, means ± SE. This number only includes $^{15}N_2O$ emission, which was not equalised by $^{14}N_2O$ uptake.

- Following a severe aphid attack, N_2 fixation dropped dramatically at 6 months.
- Translocation of fixed N from clover to companion grass represented 0.2, 1 and 1 mg N m^{-2} d^{-1} at 4, 6 and 8 months, respectively.
- The fraction of fixed $^{15}N_2$, which was emitted as $^{15}N_2O$ increased from 0.33 to 0.94 % between 4 and 6 months (Fig. 4).

Conclusions

- The results indicate that the N_2O emission factor for biologically fixed N_2 in a grass-clover pasture might be lower than the standard emission factor of 1.25 % suggested by IPCC.
- Pest status of clover is an important factor influencing the fraction of recently fixed N_2, which is emitted as N_2O – mainly because of its effect on the N_2 fixation.
- The aphid attack on clover also led to enhanced translocation of fixed N to companion grass – probably by increasing the rhizodeposition of clover.

References

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Mosier, A. et al. 1998. Nutrient Cycling in Agroecosystems 52, 225-248.

Vinther, F. P. and Jensen, E. S. 2000. Agriculture, Ecosystems and Environment 78, 139-147.

[1)] The experiment is part of a DARCOF project dealing with N_2 fixation, N_2O emissions and modelling in organic grass-clover pastures.