NITROGEN EFFICIENCY AND ENVIRONMENTAL IMPACT FROM DIFFERENT STRATEGIES FOR MANAGEMENT OF GREEN MANURE LEYS

J. Malgeryd [1] and G. Torstensson [2]

[1] JTI – Swedish Institute of Agricultural and Environmental Engineering, P.O. Box 7033, SE-750 07 Uppsala, Sweden. E-mail: Johan.Malgeryd@jti.slu.se
[2] Department of Soil Sciences, Division of Water Quality Management, SLU, P.O. Box 7072, SE-750 07 Uppsala, Sweden. E-mail: Gunnar.Torstensson@mv.slu.se

ABSTRACT

Annual green manure leys are important nitrogen sources in organic farming systems without animals. The aim of this project was to elucidate the magnitude of ammonia emissions and leaching losses from cut plant material and to identify the factors affecting these losses under field conditions.

Ammonia emissions and leaching from cut plant material were measured during a 3 year period in randomised block trials. A comparison was made between two different cutting strategies; frequent cutting (4 times per season) and less frequent cutting (2 times per season). Ammonia emissions were measured continuously for two weeks after each cutting with passive diffusion samplers (PDS) exposed in ventilated chambers and in the ambient air. In order to measure the leaching losses, precipitation water that passed through the cut plant material was collected, quantified and analysed for total N, P and C content.

Results from the first two years show that both the emission dynamics and the level of ammonia emissions are strongly dependent on weather conditions. Ammonia emissions seem to occur primarily in conjunction with the decomposition of organic material during and after moist and warm periods.

With the exception of nitrogen in 2001 and carbon in 2002, the leaching losses have been the largest in the treatment with frequent cuttings. This cutting strategy has also given rise to a less efficient utilisation of the growth potential and the nitrogen fixation capacity of the ley.

INTRODUCTION

Annual green manure leys are important nitrogen sources in organic farming systems without animals in Sweden. The green manure leys are usually cut repeatedly to reduce the amount of weeds and to stimulate crop re-growth in order to maximise the total biomass production as well as to control the crop's stage of development at the point when the ley is terminated.

Knowledge about nitrogen losses from cut plant material has so far been very limited. The existence of NH_3 emissions from cut plant material is, however, documented in the literature, e.g. by Janzen & McGinn (1991). The majority of the emission figures are based on laboratory measurements. Results from these investigations show that ammonia emissions are reduced when material dries rapidly and increase with increasing nitrogen content in the plant material. Moreover, ammonia emissions are stimulated by periodic re-wetting.

Only a few field studies are known – most of them made with the wind tunnel technique. With this technique, the plant material may not have been subjected to the shifting weather conditions. Repeated drying followed by re-wetting stimulates biodegradation and therefore probably also increases emission losses. Results from an introductory series of measurements performed by Torstensson, in which the ammonia *concentration* was measured

5 cm above the ground after cutting the green manure ley in the summer of 2000, also indicates that the emissions are markedly affected by precipitation.

The aim of this project was to elucidate the magnitude of ammonia emissions and leaching losses from cut plant material and to identify the factors affecting these losses under field conditions.

MATERIALS AND METHODS

Ammonia emissions and leaching from cut plant material were measured during a 3 year period (2001-2003) in randomised block trials with 3 replicates. A comparison was made between two different cutting strategies; frequent cutting (4 times per season) and less frequent cutting (2 times per season). Ammonia emissions were measured continuously for two weeks after each cut with passive diffusion samplers (PDS) exposed in ventilated chambers and in the ambient air. This method is described by Svensson (1993). Two chambers and one ambient condition meter were used in each plot. The exposure time was 48 hours. In order to avoid excessive disturbance from natural climatic conditions and to cover a larger soil surface area, each chamber and its content of PDS was moved between two adjacent soil frames every 24 hours. The measuring equipment is shown in Fig. 1 a.

During the whole measuring period, the soil surface temperature was recorded by a temperature logger. Climatic data for precipitation, air temperature, wind speed and wind direction were collected from a nearby meteorological station.

When measuring the leaching losses, cut plant material was placed on a wire netting on top of a collecting hopper (Fig. 1 b). Precipitation water having passed through the cut plant material was collected, quantified and analysed for total N, P and C content. Before and after each measuring period, the plant material was analysed for the above-mentioned parameters. Analyses were also made on fresh plant material above ground before terminating the ley. The mineral nitrogen content of the soil was determined through soil sampling at four different occasions during the season and in the following spring.

Figure 1. Equipment used for measuring a) ammonia emissions and b) leaching from cut plant material to soil.

RESULTS AND DISCUSSION

Results from the first two years (table 1) show that both the progress over time and the level of ammonia emissions are strongly dependent on weather conditions. Ammonia emissions seem to occur primarily in conjunction with decomposition of organic material during and after moist and warm periods.

Table 1. Nitrogen loss via ammonia emissions and leaching of N, P and C from cut plant material to soil.

Year	Nitrogen loss via ammonia emissions (kg ha^{-1})	Leaching from cut plant material to soil (kg ha^{-1})		
		N	P	C
2001	Ca 10	32-38	7-11	640-680
2002	29-37*	45-52	13-15	480-510
2003	Results not yet calculated	Ca 28	8-9	370-380

* Uncertain value due to many wet samplers

Ammonia emission results from the measurements carried out in 2003 have not yet been completely calculated. Preliminary figures, however, indicate that emission losses from the treatment with frequent cuttings were similar to those in 2002, whereas losses from the treatment with less frequent cuttings were smaller.

The leaching losses from the first year of trials are not fully comparable with the results from the following years. In 2001, the old plant material was removed each time fresh material was placed on top of the leaching hoppers. In 2002 and 2003, all plant material was left during the whole season – a practice that better reflects real conditions in the field.

With the exception of nitrogen in 2001 and carbon in 2002, leaching losses have been the highest in the treatment with frequent cutting. This cutting strategy has also led to a less efficient utilisation of the growth potential and nitrogen fixation capacity of the ley.

The mineral nitrogen content of the soil was low in both treatments, at all sampling occasions. This finding confirms that the ley is able to efficiently utilise any easily soluble mineral nitrogen available in the soil. In 2001, the mineral N content was between 10 and 15 kg per ha at all three sampling occasions (May 28, July 30 and August 27). It exceeded 15 kg per ha only at one occasion in 2003 (June 2).

CONCLUSIONS

- Both the emissions dynamics and the level of ammonia emissions are strongly dependent on weather conditions. Ammonia emissions seem to occur primarily in conjunction with decomposition of organic material during and after moist and warm periods.
- Frequent cutting (4 times per season) in most cases resulted in larger leaching losses than less frequent cutting (2 times per season). The intensive cutting strategy has also led to a less efficient utilisation of the growth potential and nitrogen fixation capacity of the ley.
- The mineral nitrogen content of the soil was low at all sampling occasions. This finding confirms that the ley is able to efficiently utilise any easily soluble mineral nitrogen available in the soil.

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