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Risks for gaseous N losses by different slurry managements

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Introduction

The utilization of plant available NH_4-N of slurries by growing plants is often unsatisfied, due to losses through N leaching and considerable gaseous losses through ammonia volatilization, denitrification (N_2O, N_2) or nitrification (N_2O). Beside environmental implications, these losses has to be compensated by mineral N fertilizer, increasing the cost for plant production.

Suitable techniques for handling slurry in the field are being improved to minimize the losses of NH_3 from slurry. On arable land, direct injection of slurry lost only 0-6% of its NH_4-N (Mannheim et al., 1995). Because of problems associated with sward damage on grassland, other techniques such as slurrry application with trailing feet resp. trailing hoses increases in importance.

From an ecological point of view, the effort to reduce NH_3 loss should be weight against the potential of other gaseous N losses (N_2O, N_2). The objective of these studies was to quantify N_2O losses from different manuring technologies, depending on their potential to reduce ammonia volatilization.

Methods

Separated cattle slurry was obtained by a roller press separator. Denitrification and N_2O emission rates were measured using a soil cover method with and without acetylene, respectively.

Experiment 1: Unseparated and separated slurry (broadcast and trailing hoses) were applied (40 kg NH_4-N ha^{-1}) to grassland to measure denitrification (with acetylene)

Experiment 2: Influence of application rate (30 resp. 60 kg NH_4-N ha^{-1}) on denitrification and N_2O emission from broadcast applied slurry to grassland

Experiment 3: Effect of trailing hoses resp. trailing feet on denitrification and N_2O emission onto grassland (40 kg NH_4-N ha^{-1})

Experiment 4: Injection of unseparated and separated slurry to maize (50 kg NH_4-N ha^{-1})

Results and discussion

Denitrification measurements using the acetylene inhibition technique showed high peaks after rainfall only in the separated slurry treated soil (Fig. 1). The application of unseparated slurry

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by trailing hoses obtained denitrification rates up to 100 g N ha^{-1} d^{-1}. However, at the end of this experiment less than 1 kg N ha^{-1} was emitted by denitrification.

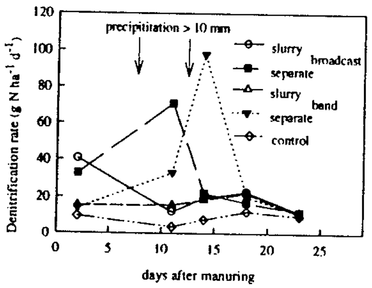

Fig. 1: Denitrification rates after different application of normal and separated slurry to grassland

In Fig. 2 the influence of different amounts of broadcast applied slurry to grassland on denitrification and N_2O emission rate is shown. Substracting the loss of the untreated control the increase of N dose from 30 to 60 kg NH_4-N ha^{-1} resulted in a doubling of denitrification, although denitrification losses were low. Changes in N_2O emission rates showed a similar pattern to the denitrification rates, with low rates for both slurry treated soils. Even in the 60 kg NH_4-N ha^{-1} treatment N_2O emission rates never exceeded 50 g N_2O-N ha^{-1} d^{-1}. Consequently, total N emission losses for a period of 30 days after manuring with and without acetylene inhibition were less than 0,6 kg N ha^{-1}.

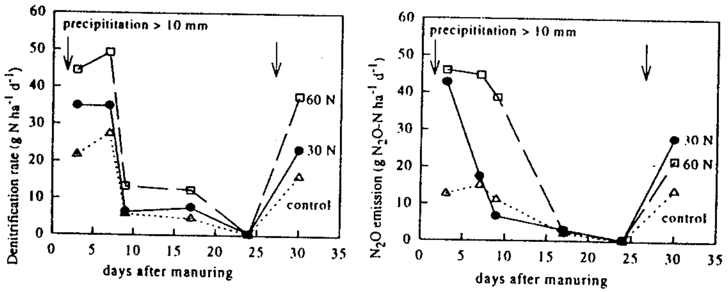

Fig. 2: Influence of different amounts of broadcast applied slurry (30 resp. 60 kg NH_4-N ha^{-1}) to grassland on denitrification and N_2O emission rates

The results of Experiment 2 showed higher losses by denitrification in the 60 kg NH_4-N ha^{-1} treatment, reflecting a higher soil nitrate content. In the same way application of separated slurry by trailing hoses resulted in lower losses of NH_3 through volatilization (Dosch and Gutser, 1995a) and therefore, the higher N content in the soil should be responsible for the increase of denitrification (Fig. 1). We conclude, that the extent of NH_3 losses from slurry immediately after manuring determines the following turnover of N resp. the content of mineral N in soil and with that also the N losses by denitrification (N_2O, N_2) and nitrification (N_2O).

The application of slurry by trailing feet is known to reduce NH_3 emissions to low values, but may also induce higher N losses by denitrification. Higher denitrification losses in the trailing feet treatment compared to trailing hoses was shown only at the 2nd sampling date (Fig. 3). Repeated preciptitation caused a daily rate up to 220 g N ha^{-1} d^{-1} in this treatment. However, total denitrification losses during the sampling period were unimportant higher (1,2 kg N ha^{-1}) than losses in the trailing feet treatment.

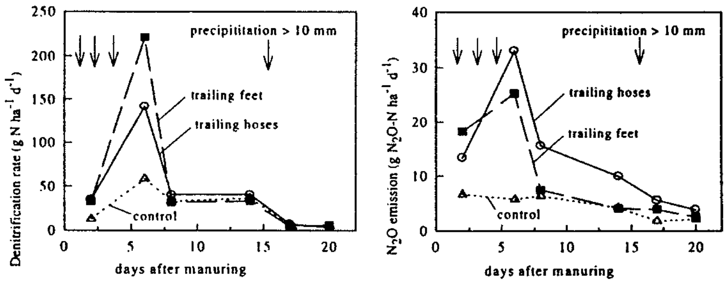

Fig. 3: Denitrification and N_2O emission rates after slurry application with trailing feet resp. trailing hoses to grassland

N_2O emission rates without acetylene inhibition of all treatments were low compared to denitrification (Fig. 3). Daily emission rates from untreated control were less than 6 g N_2O-N ha^{-1}. Slurry application by trailing feet resp. trailing hoses showed only small differences in N_2O emission rates. Until 20 days after manuring total N_2O emission losses were 0,3 and 0,2 kg N ha^{-1} from trailing feet and trailing hoses treatment, respectively.

The results of experiment 2 showed, that repeated precipitation combined with anaerobic conditions in grassland soil induced high denitrification losses, while measurements without acetylene showed only little N_2O emission rates. Therefore, with increasing anaerobie N_2 was the major form of N lost due to denitrification. Simarmata et al. (1993) observed, that the narrower the ratio of nitrate to mineralizable organic carbon, the more intensive is the release of N_2.

High denitrification losses after injection of slurry into the soil are related to their carbon content. Therefore, it should be tested, if the injection of separated slurry to maize also influences the extent of N_2O emission rates. In the first week after manuring both slurry treatments showed nearly the same N_2O emission rates (Fig. 4). Afterwards, injection of unseparated slurry caused higher N_2O losses up to 180 g N_2O-N ha^{-1} d^{-1}. Until 36 days after injection, total N_2O losses were only 2,9 kg N_2O-N ha^{-1} for the C reduced slurry compared to 4,3 kg N_2O-N ha^{-1} for normal slurry.

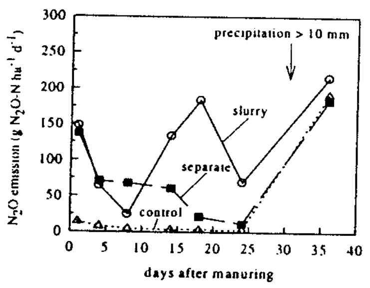

Fig. 4: N_2O emission rate after injection of normal and separated slurry from arable land with maize

Injection of slurry caused in addition to high moisture content also higher levels of nitrite within injected manure zones. Nitrite can be used by ammonium oxidizing bacteria as a terminal electron acceptor producing N_2O under conditions of oxygen stress. Therefore, both denitrification and nitrification may be responsible for the observed N_2O emission rates (Dosch and Gutser, 1995b). The less carbon will be supplied to soil by slurry, the faster it will be metabolized and therefore, the potential of N_2O losses is reduced.

Conclusion

Reducing NH_3 emissions from slurry by special distribution techniques (surface application in narrow bands, injection) or separation causes higher gaseous N losses through nitrification and denitrification. Onto grassland, spring and autumn were the seasons with the highest risks of denitrification coinciding with frequent periods of soil saturation with water. However, the predominant form of N lost due to denitrification is N_2 caused by the high carbon contents of grassland soils. Onto arable land, N_2O emission rates after injection of slurry will be decreased by lowering the carbon content of slurries (separation or anaerobic fermentation).

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