Effect of nitrogen-reduced diet on NH_3 and N_2O emissions of dairy cows on pasture

Christof Ammann[1], Karl Voglmeier[1] and Daniel Bretscher[1]

[1] Climate and Agriculture Group, Agroscope Research Institute, Zürich, Switzerland

E-mail: christof.ammann@agroscope.admin.ch

Abstract

The NH_3 and N_2O emissions from two parallel pasture-based feeding systems with dairy cattle were measured. In one system cows were fed exclusively on pasture grass, in the other system 25% maize silage was supplemented. This resulted in a reduced protein-to-energy ratio in the M diet, and correspondingly the amount of excreted nitrogen was decreased by about 19%. The obtained results showed that the default N_2O emission factor currently used in the Swiss greenhouse gas inventory is probably too high. The study demonstrated that protein-reduced feed can contribute to a reduction in NH_3 and N_2O emissions on the pasture.

Keywords: NH_3, N_2O, dietary effects, mitigation, emission, grazing

1. Introduction

Grazing related emissions of N_2O and NH_3 typically depend on the excreted nitrogen (N) by the animals on the pasture soil. Studies have shown that an optimized feeding strategy can lead to less N excreted by the animals. For this purpose, forage with a low N content (e.g. maize) can be used as a supplement to N rich grass and this subsequently leads to less N in the excreta N and supposedly in less N_2O and NH_3 emissions. However, corresponding emission experiments under real grazing conditions are rare, and thus emission factors (EF) used in national inventories are uncertain.

2. Methods

During the experiment, NH_3 and N_2O fluxes were measured simultaneously on two neighbouring grazing systems over a full grazing season in 2016. Each pasture was grazed by 12 dairy cows in a rotational grazing management and the diet of the herd consisted of different N:energy ratios (system G: grass only diet, system M: grass with additional maize silage) resulting in about 19% lower N in the excreta in system M. The NH_3 concentrations up- and downwind of an emitting paddock were measured with line-integrating miniDOAS devices (Sintermann et al., 2016) and the emissions were calculated by applying a backward Lagrangian stochastic dispersion model (bLS; Häni et al., 2018) to the concentration differences. The field scale emissions of N_2O were quantified using the eddy covariance technique whereas the temporal pattern and magnitude of underlying small-scale emissions were measured with a fast-box chamber.

3. Results and discussion

The average NH_3 emission per grazing hour and cow was about 40% lower on system M compared to system G, and resulted in relative EFs of 6.4 ± 2.0% and 8.7 ± 2.7% for systems M and G, respectively (Voglmeier et al., 2018). These EFs agree well with the one used in the Swiss emission inventory. Similary, the N_2O emissions per cow were about 25% lower in system M. However, N_2O EFs were much lower (below 1%; Voglmeier et al., 2019) compared to the default EF of 2% provided by the IPCC guidelines, which is currently used in the Swiss greenhous gas inventory. In summary, the N-reduced diet resulted in significantly lower emissions for both trace gases. Moreover, the study showed that grazing-related N_2O emissions may be overestimated in the current Swiss inventory.

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References

Häni, C., Flechard, C., Neftel, A., Sintermann, J., Kupper, T. 2018 Accounting for Field-Scale Dry Deposition in Backward Lagrangian Stochastic Dispersion Modelling of NH_3 Emissions *Atmosphere* **9** 146-169

Sintermann, J., Dietrich, K., Häni, C., Bell, M., Jocher, M., Neftel, A. 2016 A miniDOAS instrument optimised for ammonia field measurements *Atmospheric Meas. Tech.* **9** 2721–2734

Voglmeier, K., Jocher, M., Häni, C., Ammann, C. 2018 Ammonia emission measurements of an intensively grazed pasture *Biogeosciences* **15** 4593–4608

Voglmeier, K., Six, J., Jocher, M., Ammann, C. 2019 Grazing-related nitrous oxide emissions: from patch scale to field scale *Biogeosciences* **16** 1685–1703