Eco-efficiency of irrigated dairy pastures in South Africa: N_2O Emissions from managed soils and its implication for carbon footprint calculations.

Measurements of nitrous oxide from irrigated, pasture-based dairy systems in South Africa indicated that excessive N-fertilizer use above plant demand contribute significantly to climate change and consequently to the carbon footprint of dairy products.

Author

- Name: Hendrik P.J. Smit, Thorsten Reinsch, Pieter A. Swanepoel, Christof Kluß and Friedhelm Taube
- Organization: Christian-Albrechts-University Kiel, Germany; Stellenbosch University, South Africa
- Location: Outeniqua Research Farm, George, South Africa
- Email address: hsmit@gfo.uni-kiel.de; treinsch@gfo.uni-kiel.de; pieterswanepoel@sun.ac.za; ckluss@gfo.uni-kiel.de; ftaube@gfo.uni-kiel.de

Summary

- Resource based measure:
    - Measure 1: GHG emissions
    - Measure 2: Nitrogen fertilizer effects on pasture production and quality
    - Measure 3: Nitrogen inputs to pastures from animal excreta
- Animal based measure:
    - Measure 1: Direct N2O emissions from managed soils
    - Measure 2: Emission factors (EF) associated with mineral fertilizer
    - Measure 3: Nitrogen surplus as a result of mineral fertilization and manure inputs
- 3. SDGs: 12: Responsible Consumption and Production; 13: Climate Action; 15: Life on Land

Proving an update to South Africa´s greenhouse gas inventory

Fertilized agricultural soils serve as a primary source of anthropogenic N_2O emissions, a greenhouse gas with a globing warming potential 265 times that of CO_2. In South Africa, there is a paucity of data on N_2O emissions from fertilized, irrigated dairy-pastures and emission factors (EF) associated with the amount of N fertilized. However, it is important to create country-specific EFs to quantify emission hot-spots and subsequently promote mitigation strategies to ensure climate smart dairy production. This study could update South Africa´s greenhouse gas inventory more accurately and can promote ways to produce more environmentally friendly milk with low associated greenhouse gas emissions and therefore a lower carbon footprint.

The aim was to obtain quantitative values for N_2O emissions and to use it to calculate the carbon footprint of milk more accurately from pasture-based dairy systems in South Africa and to investigate the effect thereof on the environment. We evaluated the effect of different N fertilizer rates on N_2O emission on grazed pastures.

Field trials performance

Field trials were laid out as a randomized block design to evaluate five N fertilizer rates (0, 220, 440, 660 and 880 kg N ha-1 year-1) as treatments, replicated in four blocks, on N_2O emissions from irrigated kikuyu-perennial ryegrass (Pennisetum clandestinum-Lolium perenne) pastures. N_2O emissions were captured using the static chamber method. Gas measurements were performed for one year on a weekly basis unless in the case of a fertilization event, where it was done in three consecutive days after fertilization. Gas samples were analysed for N_2O through a gas chromatograph to determine daily fluxes. Cumulative fluxes were calculated by means of linear interpolation.

The suggested Emission Factors of the IPCC default value for grazing systems led to an overestimation of N_2O emissions.

Results shown that excessive fertilization of N will add directly to N_2O emissions from the pastures. The study accumulated N_2O emissions ranged between 2.45 and 15.5 kg N_2O-N ha-1 year-1 and EFs for mineral fertilizers applied had an average of 0.9%. However, EF for N-deposition from animal excreta seemed to be overestimated. Taking the N-excreta into account, the excessive use of mineral fertilizers on pastures in South Africa resulted in high N surpluses (>400 kg N ha-1 year-1). Thus, the relationship between N_2O-N losses and N input can best be described by an exponential function rather than a linear function. There was no positive effect on growth of pasture herbage from adding N at high rates.

A better approach would be to replace EFs of the IPCC default value with regional EF values, which are dependent on the N balance. This leads to more accurate greenhouse gas inventories from managed soils on a regional scale, where other environmental threats (e.g. groundwater pollution and eutrophication) are also addressed. Results from this study could be further used to calculate regional and management specific carbon footprint for dairy products, which opens new opportunities for producers and the market.

The pilot study was the first to measure GHG emissions from predominantly grassland and forage systems in South Africa

The next approach is to calculate the regional specific carbon footprint of milk produced under different pasture management scenarios, using the equations developed from this study. This will give a new insight into the opportunities for producing climate-smart dairy products in South Africa.

References

Smit, H.P.J., Reinsch, T., Swanepoel, P.A., Kluß, C., 2020. Grazing under Irrigation Affects N2O-Emissions Substantially in South Africa. Atmosphere 2020, 11(9), 925. https://doi.org/10.3390/atmos11090925

Viljoen, C.; van der Colf, J.; Swanepoel, P.A. Benefits are limited with high nitrogen fertiliser rates in kikuyu-ryegrass pasture systems. Land 2020, 9, 173. http://doi.org/dxhs