Can digestate application improve nitrogen use efficiency, reduce nitrate leaching and greenhouse gas emissions in organic cropping? Mayer, J.[a]*, Scheifele, M.[a], Diener, M.[a], Agostini, L.[b], Krause, H.-M.[b], Efosa, N.[b] & Bünemann-König, E.[b]

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Introduction

The European Union's Green Deal strategy aims to reduce nutrient losses in agriculture by 50% and fertilizer use by 20%. Reducing nitrogen (N) losses – ammonia (NH3), nitrate (NO3) and nitrous oxide (N2O) – by manure processing and further field application and management will be a key measure to improve organic fertiliser nitrogen use efficiency (NUE) by crops and meet EU reduction goals. Anaerobic digestion of manure and organic waste generates renewable energy and contributes to close nutrient cycles. It is also suggested as an option to improve NUE in organic cropping, but possible trade-offs like increased NH3 losses, N2O emissions or NO3 leaching are not well understood. Biochar amendments to digestate has been advocated to decrease N losses. The aim of this study was to understand the benefits and trade-offs of digestion of manure and organic waste as well as biochar amendments to digestate compared to undigested liquid manure under organic cropping.

Methodology

We set up a comprehensive field study in Switzerland with digestate from liquid manure with and without biochar amendments and a liquid digestate from an organic waste digestion plant and compared it to undigested liquid manure, mineral fertilization and a zero N control. The study started in 2018 and is still ongoing. We assessed yields, NUE, NH3 losses and N2O emissions and mirrored the experiment in the Agroscope-Zurich lysimeter facility to evaluate NO3 leaching. The ammonium (NH4) N fraction of fertilizers was 15N traced and allowed to study the initial NH4-N flows over three crops (silage maize – winter wheat – winter barley). N application rates were based on total N content of fertilisers (120 - 140 kg N ha-1). We show results from the first 3 years period.

Results and discussion

Crop yields differed only slightly in maize and wheat. However, in barley digestate produced comparable yields to the mineral fertilization, but undigested liquid manure was significantly lower. Apparent NUE of manure-based digestate tended with 30% to be greater than for undigested liquid manure with 26%. A decrease rather than an increase in apparent NUE was observed when digestate was amended with biochar at 2 t ha-1 yr-1. Crop NH4-N recovery in the year of application was only 36 % for mineral and 16% for organic fertilizers in maize due to the very dry summer 2018, but in wheat in 2019 75% of NH4-N was recovered from mineral fertilizer, 52% to 62% from digestate, but only 40% from undigested liquid manure. Low NH4-N recovery could be explained by partly high NH3 losses after application, which were significantly higher in digestate, 42% of applied, compared to undigested liquid manure with 31%. Emissions of N2O tended to be increased by application of liquid organic compared to mineral fertilizers, but were mainly driven by soil temperature, soil moisture and soil mineral N. NO3 leaching was low and did not exceed 25 kg NO3-N ha-1yr-1 (Bünemann and Mayer 2021).

Conclusion

Overall digestion could be a measure to reduce N limitations in organic cropping with small environmental trade-offs if NH3 losses after application can be reduced. Biochar additions had no beneficial effect on N losses. A second phase of project (2022 – 2025) will focus on N-loss reduction technologies with slurry acidification and NH4-stripping (see poster Agostini et al.).

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References

Bünemann, E., Mayer, J. 2021. Optimal use of recycled fertilisers in organic farming: yield effect and nitrogen use efficiency. Final report – Federal Office of Agriculture, Switzerland, 65p.