Emissions of Greenhouse Gases from Biogas Crop Production Systems

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There is a growing concern that greenhouse gas (GHG) emissions during agricultural energy crop production might negate GHG emission savings (CO_2 neutral) which was not intended when promoting the use of renewable energy. Most bioenergy cropping systems require intensive fertilizer inputs including nitrogen. As soil nitrous oxide (N_2O) emissions are likely to be the dominating greenhouse gas emissions associated with bioenergy crop production, better estimation of N_2O fluxes (site-specific or crop-specific) is needed to make reliable life cycle analysis of bioenergy production. In spite of their high relevance, we still have limited understanding of the complex underlying microbial processes that consume or produce N_2O and their interactions with soil types, fertilizers (rate and types), plants, and other environmental variables. Therefore, present study aims to contribute to the understanding of the complex relationships between factors influencing especially N_2O emission in different bioenergy crop production systems.

In a 2-year field experiment, we compared two important biogas crops in two different agro-ecological regions of northern Germany for their productivity and GHG emissions, using the closed chamber technique with high time-resolution sampling. Additionally, we conducted number of laboratory incubation experiments, with the objective to test the impact of the application of various N containing organic substrates (e.g. cattle and pig slurry) including biogas residue on the denitrification rate, N_2O emission, and the $N_2O/(N_2O + N_2)$ product ratio of soil. In the incubation experiments, stable isotope labeling study clearly showed that denitrification was the major source (over 90% of emitted N_2O) of large N_2O peaks that occurred immediately after fertilizer application. Application of organic fertilizers with large amounts of labile C induced drastic increases in the soil denitrification rate, however biogas residue was more recalcitrant to decomposition than other organic fertilizers tested, despite a high concentration of soluble organic C. Overall field experiments, N_2O emissions were 20–30% higher in soils planted with energy crop maize than with grass. However, energy yield (methane production per unit acreage) was almost threefold higher with maize crop than with grass. We summarize present knowledge on GHG emissions which is relevant for development and implementation of mitigation measures focusing on high input bioenergy crop production systems.