Greenhouse gas emission from soils of bioenergy crop production systems and regulating factors

MSc Mehmet Senbayram 1. Berichterstatter: Priv.-Doz. Dr. K. Dittert

There is now very broad scientific evidence that most of the observed increase in global average temperatures since the mid-20th century is due to the increase in anthropogenic greenhouse gas emissions into the atmosphere. In order to mitigate these emissions, for example in Germany, biogas production has now become a major strategy for sustainable use of energy crop biomass as renewable energy source. Like almost all crops, energy crops require intensive nitrogen inputs for their production. However this generally leads to large N_2O losses in the course of biological nitrogen transformation processes in the soil, i.e. nitrification and denitrification. In the present PhD study I aimed to contribute to the understanding of variations in denitrification- and nitrification-derived N_2O emissions from soils supplied with biogas waste and compared with other inorganic and organic fertilizers using ^{15}N-labelling techniques under fully controlled conditions. Processes producing N_2O have been determined, and effects of soil moisture, N rates, and availability of organic matter were tested. Additionally, a two-year field experiment has been set-up in order to evaluate two favourable biogas crops in two agro-ecological regions of Northern Germany for their productivity and GHG emissions. The field experiment was conducted at two sites with different soil types but similar temperate maritime climate. A number of pot experiments has been done including an isotope labelling study which indicated that 65-95 % of all emitted N_2O was derived from denitrification for all fertilizer types tested. However, when studying the effect of soil moisture, the ratio of denitrification/nitrification derived N_2O was lower at 65% than at 85% WHC. So it is speculated that application of organic matter in conjunction with ammonium nitrogen first leads to a decrease in denitrification-derived N_2O emission compared to soil receiving mineral fertilizer. However, at later stages when denitrification becomes C-limited, higher N_2O emissions would be induced when the soil moisture is high. In the two year field experiment, flux patterns indicated pronounced effects of soil moisture which was also seen as responsible for the 10–72 % higher N_2O fluxes in bioenergy maize compared to the two other bioenergy crops tested (wheat and ryegrass). Overall, N_2O emissions at site Hohenschulen with a loamy soil were at least 2 times higher than in all crops examined at site Karkendamm with sandy soil. The biomass yield-related evaluation revealed that N_2O emissions per unit dry matter were 285 and 151 g N_2O-N / ton DM at site Hohenschulen and site Karkendamm respectively. As energy crops for biogas production need to be grown in sustainable crop rotations, the present study provides a very good basis for the assessment of direct emissions of greenhouse gases from relevant biogas crops in North-West Europe.