Geophysical Research Abstracts
Vol. 18, EGU2016-16852, 2016
EGU General Assembly 2016

N_2O and CH_4-emissions from energy crops - Can the use of organic fertilizers in form of biogas digestate be considered as a real alternative? Results from a three and a half year multi-site field study of energy crops fertilized with biogas digestate in southern Germany, Ascha.

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Together with industrial process-related emissions (8.1%) the actual GHG emissions from agriculture (7.5% - 70 million tones (Mt) of carbon dioxide (CO_2)-equivalents) representing after energy-related emissions from combustion processes of fossil fuels (83.7%) the second largest budget of the Germany-wide total emissions per year. To reduce the EU's CO_2 emissions by 20% by 2020 the cultivation of energy crops for biogas production, ideally coupled to a subsequent return of the resulting residues in form of biogas digestate is intended as one key element in the pathway of renewable energy production. Despite an increasing cultivation of energy crops for the production of biogas aiming to reduce the overall climate impact of the agricultural sector, it is still largely unknown how the application of ammonia-rich organic digestate effects field N_2O emissions. Therefore, the collaborative research project "potential for reducing the release of climate-relevant trace gases in the cultivation of energy crops for the production of biogas" was launched. The main objective of the study was to determine an improved process understanding and to quantify the influence of mineral nitrogen fertilization, biogas digestate application, crop type and crop rotation, to gain precise and generalizable statements on the exchange of trace gases like nitrous oxide (N_2O) and methane (CH_4) on the resulting climate impact. Gas fluxes of N_2O and CH_4 were measured for three and a half years on two differently managed sites in maize monoculture with different applied organic N amounts and in a crop rotation system called FFA and FFB with same amounts of applied N but three different forms of N application (mineral N, mineral+organic N, organic N).

The annual cumulative N_2O exchange rates in maize monoculture showed a clear dependence on the amount of applied organic fertilizer. Average annual cumulative exchange rates ranged from 1.65 $\pm$ 0.74 kg N ha^{-1} yr^{-1} to 11.03 $\pm$ 1.63 kg N ha^{-1} y^{-1}explainable by a twice as high amount of N compared to the conventional fertilized site. The average annual cumulative CH_4 exchange rates in maize monoculture varied between -1.2 $\pm$ 0.46 kg C ha^{-1} yr^{-1} and 3.75 $\pm$ 0.48 kg C ha^{-1} y^{-1}with measured CH_4 fluxes around zero between the fertilizing events, indicating a minor role. For FFA and FFB the average annual cumulative N_2O exchange rates ranged from 1.45 $\pm$ 0.18 kg N ha^{-1} yr^{-1} to 3.5 $\pm$ 1.1 kg N ha^{-1} y^{-1}and 1.37 $\pm$ 0.57 kg N ha^{-1} yr^{-1} to 1.71 $\pm$ 0.29 kg N ha^{-1} y^{-1} andshowed lower values to comparable treatments in the maize monoculture especially indicating the different management effects. Determined average annual cumulative CH_4 exchange rates ranged from 0.19 $\pm$ 0.6 kg C ha^{-1} yr^{-1} to 0.21 $\pm$ 0.45 kg C ha^{-1} yr^{-1}and -0.8 $\pm$ 0.7 kg C ha^{-1} y^{-1} to 1 $\pm$ 0.6 kg C ha^{-1} y^{-1} and played as well a minor role. Altogether, biogas digestate can be seen as a suitable alternative if the amounts of applied N selected appropriately in combination with a customized management.