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Land-use history and management intensity as drivers of spatial variability in soil greenhouse gas fluxes in a poplar bioenergy plantation

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Bioenergy crops are considered to be carbon-neutral because biomass combustion releases only carbon which has previously been extracted from the atmosphere by the plants. However, during crop growth, a significant amount of the greenhouse gases (GHG) CO_2, CH4 and N2O can be produced by soil microorganisms and released to the atmosphere. Depending on crop type and management intensity, soil GHG fluxes might be so substantial that bioenergy crops could overall emit more GHG than the same amount of fossil fuels. The present knowledge about soil GHG fluxes from bioenergy crops is not sufficient to accurately quantify them. This is especially true for short rotation woody crops (SRWC) which might become more important in the future because they have a relatively high GHG mitigation potential. However, before pursuing the use of SRWC plantations for carbon sequestration and fossil fuel replacement, it is necessary to accurately assess their uptake and release of all major GHG to prevent the unconscious widespread deployment of unsustainable cultivation practices.

The aim of this project is to identify drivers of spatial variability in soil GHG fluxes in a poplar SRWC plantation with special emphasis on the legacy effect of former land-use. The plantation has been established partly on former pasture and partly on former cropland, offering the unique opportunity to study soil GHG flux dynamics with respect to their dependency on former land-use type under identical climate and management conditions. The plantation is currently in its fifth vegetation season and in the first year of its third rotation. Simultaneous monitoring of soil CO_2, CH4 and N2O fluxes will take place with a custom-made automated chamber system throughout the entire third rotation (three years) accompanied by soil gas concentration profile measurements. In parallel, community composition of functional groups of soil microorganisms (denitrifiers, ammonia oxidizers, methanogens) and total soil microbial biomass will be quantified at different developmental stages of the poplar plantation as well as in adjacent long-established and newly converted agricultural fields. The microbial community data will give a quantitative overview of the spatial variability of these functional groups in a highly patterned agricultural landscape and new insights into the effect of different types of disturbance events (e.g. land-use change, harvest) on the composition of functional groups of soil microorganisms and the time duration of possible acclimation effects. In combination with the soil GHG flux dataset, this research will result in new significant insights into the importance of environmental controls versus microbial community composition for soil GHG flux dynamics in bioenergy crops. The interpretation of the data will be aided by a vast database containing information on ecosystem GHG fluxes, soil CO_2 fluxes, above-ground and below-ground biomass development, as well as groundwater chemistry, which has been collected since the establishment of the plantation in 2010 in the POPFULL project (http://webh01.ua.ac.be/popfull/).

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