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Soil greenhouse gas fluxes from a poplar bioenergy plantation: How long does former land use type matter?

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The cultivation of fast-growing tree species for the production of bioenergy – known as short rotation woody crops (SRWC) – is considered to be carbon-neutral because biomass combustion releases only carbon which has previously been extracted from the atmosphere via photosynthesis. The true greenhouse gas (GHG) mitigation potential of SRWC, however, remains largely unknown due to limited knowledge on the amount of GHG released from the soil during cultivation, and the soil organic carbon (SOC) sequestration rate over time. Especially measurements of the complete GHG balance of SRWC plantations which have already been managed for several years are lacking. The aim of this study was to quantify the spatial and temporal variability of soil GHG fluxes in a SRWC plantation with poplar located in Lochristi, Belgium (POPFULL, http://uahost.uantwerpen.be/popfull/). The plantation has been established in April 2010 partly on former cropland and partly on former pasture, enabling us to study the dependency of soil GHG fluxes on former land use type under identical climate and management conditions. Furthermore, spatial differences in the SOC content created by alternating row spacings between poplars were studied. The plantation was harvested in February 2012, and in February 2014. Soil CO_2, CH_4, N_2O and CO fluxes were simultaneously monitored with automated closed dynamic chamber systems from May 2013 until August 2014, embracing a pre- and post-harvest period. The chamber measurements were accompanied by fortnightly measurements of soil gas concentrations in the top- and subsoil (2013: CO_2 and O_2, 2014: CO_2, CH_4, and N_2O). Preliminary results show that former pasture and cropland areas were still distinguishable within the plantation based on properties such as weed composition, dry bulk density and SOC content. During a drought period in August 2013, soil CO_2 fluxes seemed to be slightly higher from the former cropland area, but no apparent effect of former land use type was observed during non-drought periods. Soil CO_2 fluxes were mainly affected by the current land use type, with flux rates being significantly higher from narrow compared to wide rows. Soil CH_4 fluxes were very low, with the majority of the fluxes ranging between -80 μg m^{-2} h^{-1} (soil CH_4 uptake) and +80 μg m^{-2} h^{-1} (soil CH_4 release). The same was true for soil N_2O and CO fluxes (0 to 25 μg m^{-2} h^{-1} and -100 to 0 μg m^{-2} h^{-1}, respectively). Higher N_2O fluxes were sometimes measured after heavy rainfalls, but spatial variability was too high to clearly identify soil legacy effects on soil N_2O flux rates. In conclusion, after five years of SRWC cultivation no apparent differences in the GHG flux rates were found anymore between former cropland and pasture areas. This result is in contrast to POPFULL measurement campaigns performed during the first vegetation season of the plantation, where soil CO_2 fluxes were significantly higher from former pasture.

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