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Soil greenhouse gas fluxes following tropical deforestation for fertilizer-intensive sugarcane cultivation in northwestern Uganda

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Deforestation followed by fertilizer intensive agriculture is widely recognized as a significant contributor to anthropogenic greenhouse gas emissions (GHG), particularly carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). However, empirical studies focusing on soil GHG flux dynamics from deforestation hotspots in the tropics are still limited creating major uncertainties for constraining global GHG budgets. In this study, we investigated how deforestation for fertilizer intensive sugarcane cultivation in Uganda affects soil-borne GHGs. Therefore, soil GHG fluxes were measured in a primary forest and in a completely randomized experiment premised in the neighboring sugarcane fields with different fertilizer regimes, representing both smallholder and industrial-scale sugarcane farm management. Despite the use of different fertilization rates (low, standard, and high) as treatments for the sugarcane CRD experiment, neither auxiliary controls nor soil GHG fluxes significantly differed among the CRD treatments. Soil respiration was higher in the sugarcane than in the forest, which we attribute to the increased autotrophic respiration from the sugarcane's fine root biomass and the likely exposure of the sugarcane's larger soil organic carbon stocks to microbial decomposition through ploughing operations. The forest soils were a stronger net sink of CH_4 than the sugarcane soils despite forest soils having both higher bulk densities and larger water-filled pore space (WFPS), and we suspect that this was due to alteration of the methanotroph abundance upon the conversion. Soil N_2O emissions were smaller in the sugarcane than in the forest, which was surprising, but most likely resulted from the excess N being lost either through leaching or uptake by the sugarcane crop. Only seasonal variability in WFPS, among the auxiliary controls, affected CH_4 uptake at both sites and soil CO_2 effluxes in the sugarcane. Noteworthy, soil N_2O fluxes from both sites were unaltered by the seasonality-mediated changes in auxiliary controls. All the findings put together suggest that forest conversion for sugarcane cultivation alters soil GHG fluxes by increasing soil CO_2 emissions and reducing both soil CH_4 sink strength and soil N_2O emissions.