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Sphagnum farming on former peat extraction sites - a climate-neutral production system?

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Restoration projects aim to turn drained and degraded peatlands back into their original state as sinks of atmospheric carbon dioxide (CO_2). A promising way of combining ecological and economic goals is paludiculture, i.e. biomass production under wet and peat preserving conditions. Here, we evaluate the attempt of commercial Sphagnum farming on former peat extraction sites in northwestern Germany, which are, in contrast to previous Sphagnum farming experiments, characterized by strongly decomposed "black" peat and rather large in scale ($>$ 5 ha). Over a period of two years, we monitored the development of bryophyte and vascular vegetation and measured the exchange of CO_2, methane (CH_4) and nitrous oxide (N_2O) using manual static chambers. Experimental sites were a near-natural bog, an irrigation polder and two cultivation sites. One of the cultivation site was established directly after termination of the peat extraction, while the other one has been rewetted as a shallow polder for seven years before the establishment. Special emphasis has been placed on the influence of different irrigation techniques and of potential future climate warming conditions. For the latter purpose, selected plots were equipped with Open Top Chambers (OTC).

Water management had a strong impact on groundwater levels, Sphagnum growth and thus on the greenhouse gas exchange. Previous rewetting seemed to improve the soil hydrological conditions, while drip irrigation provided more favorable conditions during the initial phase of Sphagnum farming than ditch irrigation. Despite all efforts, the extraordinary hot and dry summer of 2018 resulted in low water table depths and a stagnation of Sphagnum growth. Due to the slow development of the peat mosses during the establishment phase and due to temporary droughts, most sites were still net sources of CO_2. Besides the near-natural reference site, only one of the Sphagnum cultivation sites was a small sink of CO_2. Highest CH_4 emissions were measured at the near-natural site followed by the irrigation polder, while CH_4 fluxes from the cultivation sites were low. N_2O emissions from the two cultivation sites were higher than expected. A large N_2O peak was measured after a dry period at the ditch irrigation site, which showed low vegetation cover and thus negligible nitrogen uptake. The OTC slightly increased air and soil temperature, which led to higher emissions of CH_4, N_2O and CO_2. Surprisingly, the latter can rather be explained by a lower primary production than by an increased respiration.

Our results demonstrate the general feasibility of Sphagnum farming under the challenging conditions of strongly decomposed peat, although growth was lower than on weakly decomposed peat and an elaborated water management system is absolutely essential for success.