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Groundwater level management in peat pastures: trade-offs between yield, N_2O and CO_2 emissions

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Draining peatlands for agricultural use is associated with large emissions of CO_2 to the atmosphere because of peat decomposition. In countries with significant amounts of agricultural peatlands, such as the Netherlands, raising the groundwater level (GWL) using a variety of techniques is explored as a measure to mitigate CO_2 emissions. However, these measures risk trade-offs with yield as well as with N_2O emissions. Here, in two experiments we quantify the effects of GWL management on these trade-offs in pastures on peat soil in the Netherlands. First, in a five year field experiment on an experimental farm N_2O and CO_2 emissions as well as grass yield were measured on four fields differing in ditch water level (DWL; on average -20 cm vs -50 cm) as well as active vs passive groundwater infiltration. Subsequently, we studied GHG emissions in more detail in a one year lab experiment with large (1 m height, 24 cm diameter) undisturbed and unfertilized bare peat columns from the same site as well as from two additional locations. The column experiment also allowed us to explore more constant and more extreme GWLs, ranging from 0 to -150 cm. Under unfertilized conditions, increasing the DWL did not affect CO_2 emissions in the field. However, N_2O emissions decreased from approx. 4.5 to 2.2 kg N_2O-N ha^{-1} yr^{-1} and yield from 10.3 to 8.8 Mg ha^{-1} yr^{-1}, both probably reflecting a reduction in N mineralization. At high DWL (-20 cm), active groundwater infiltration resulted in lower CO_2 emissions than either passive infiltration or the control without infiltration. After fertilization, emission factors ranged from 2.5% of applied N for cattle slurry to 5.2% for calcium ammonium nitrate. No significant relations between N_2O emissions and infiltration type or DWL level were detected. In the column experiment, effects of GWL on CO_2 emissions were more pronounced, with highest emissions at a GWL of -80 and a large emission reduction at GWLs close to 0. However, N_2O emissions of the unfertilized columns were strongly increased when GWLs varied between 0 and -20 cm, resulting in higher GHG emissions in terms of CO_2-equivalents than at drier conditions. Our results show complex relations between water management and CO_2, N_2O and yield in peat soils, with no obvious strategy to find an optimum. The results from our column experiment suggest that total inundation without fertilization would result in minimal GHG emissions, but this could obviously not be combined with any traditional forms of farming and may result in methane emissions. Our field experiment suggests that the combination of high DWL with active infiltration systems results in lower CO_2 emissions at a relatively small yield penalty. However, for large-scale implementation of such a system, the costs of the technical setup have to be considered, as well as the relatively small reduction in CO_2 emissions.

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