Peat pasture productivity with raised groundwater tables

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Abstract

Dutch peatlands have long been drained to be used primarily as pastures for dairy production, improving productivity but causing high greenhouse gas (GHG) emissions and soil subsidence due to peat degradation. Raising the groundwater table (WT) from the conventional 50 cm below field level to 20 cm using an active water infiltration system (AWIS) is a possible solution to reduce peat degradation. This paper highlights the effect of raising WT on grass production and soil nitrogen supply (SNS) by using experimental plots with different WT and fertilisation levels from 2020–2024. Regression analyses resulted in an average decrease of 11% in herbage dry matter yield (DMY) when raising WT from 50 to 20 cm below field level, with significant variation between years. The reduced DMY could be explained by the decrease in SNS in wetter conditions, due to a lower mineralisation rate. Increased N fertilisation could mediate DMY losses, but N losses from soil would increase. Although results were obtained at plot level, and exclude losses from harvesting and grazing, they indicate that raising WT is compatible with relatively high grass production.

Keywords: active water infiltration systems (AWIS), grass yield, dairy, nitrogen, peat soil

Introduction

In The Netherlands, peat soils are predominantly used as permanent pasture for dairy production. A long history of drainage of peat soils has resulted in productive pastures, with a high soil N supply (SNS) due to oxidation of the peat layer and historic additions of manure and slurry (Pijlman *et al.*, 2020). Drainage of peat soils, however, also leads to high greenhouse gas (GHG) emissions and soil subsidence (Poppe *et al.*, 2021). In the Climate Agreement, the Dutch government aims to reduce GHG emissions from peat soils by 1 million tons of CO_2 equivalents and reduce soil subsidence by 50% by 2030. The most prominent solution to reach this aim is to rewet previously drained peat soils, by increasing the groundwater table. Raising groundwater tables can be achieved by making use of an active water infiltration system (AWIS), which consist of pressurised submerged drains that can regulate the groundwater table throughout the year (Hoving *et al.*, 2021). Raising groundwater tables affects dairy farm management, as the wetter conditions alter soil conditions. In particular, raising groundwater tables can reduce the mineralisation rate of the peat layer, resulting in less available nitrogen for the grass to take up, leading to reduced grass production and quality (de Vos *et al.*, 2010). Here, we explore how raising groundwater tables affects herbage dry matter yield and SNS.

Materials and methods

Data were collected at the experimental farm KTC Zegveld from 2020–2024. The experimental farm was equipped with two separate farming systems, a high-water system (HW, target groundwater table of 20 cm below field level) and a low-water system (LW, target groundwater table of 50 cm below field level) (van Dijk *et al.*, 2026). Each system was equipped with experimental plots (HW, $n = 9$, LW $n = 6$), which were divided into three strips (2.5×10 m). Each strip was treated with a fertilisation rate of 0, 125 or 250 kg N ha^{-1} year^{-1} in the form of calcium ammonium nitrate (CAN). In the HW system, the target groundwater table of 20 cm below field level was regulated with the AWIS, while in the LW system, no AWIS was present. Groundwater tables were measured in every plot every two weeks, and averaged over the growing season. The average measured groundwater table was significantly different between HW and LW (average of 27 and 45 cm below field level for HW and LW respectively). The three strips per plot were harvested in 4–5 cuts per year, and the herbage dry matter yield (DMY, kg ha^{-1} year^{-1}) was determined. SNS (kg N ha^{-1} year^{-1}) was calculated as the N yield without fertilisation. The main effects and interactions of groundwater table (in cm below field level), N fertiliser and year (2020–2024) were estimated with a linear mixed model using R studio.

Results and discussion

Both DMY and SNS were significantly ($P < 0.001$) affected by the main effects of groundwater table and year. For DMY, this resulted in an average decrease of 44 kg DM ha^{-1} year^{-1} per cm increase in groundwater table, which is shown in Figure 1. DMY differed per year, with an average increase of 967 kg DM ha^{-1} year^{-1} (range 208–2036) compared to 2020. The predicted reduction in DMY when increasing the groundwater table from −50 cm to −20 cm was on average 1.4 Mg DM ha^{-1}, or an 11% decrease. In addition, the significant main effect of fertilisation ($P < 0.001$, not shown in Figure 1) resulted in an increase of 10 kg DM ha^{-1} year^{-1} per kg of fertiliser N applied, without being affected by year or groundwater table (average of 10.3, 11.7 and 12.9 Mg DM ha^{-1} year^{-1} with 0, 125 and 250 kg N ha^{-1} year^{-1} respectively). N fertilisation could therefore be used to compensate the losses in yield, but increased fertilisation results in further N losses to the environment, which could counteract the climate gains from raising groundwater tables (van der Laan *et al.*, 2024).

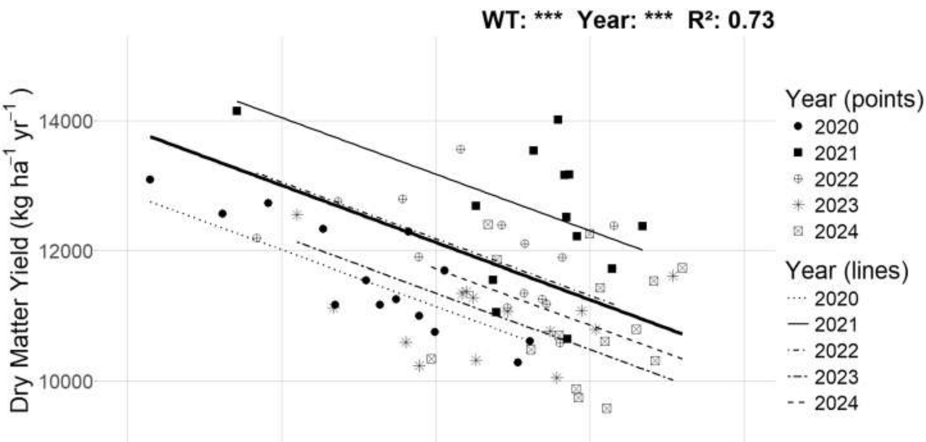

Figure 1. Dry Matter Yield (DMY, in kg ha^{-1} year^{-1}) fertilised with 125 kg N ha^{-1} year^{-1}, across the average measured groundwater tables (WT) per plot in 2020–2024. The thick black line indicates the average effect over the 5 years.

SNS decreased on average by 1.2 kg N ha^{-1} $year^{-1}$ per cm increase in groundwater table. SNS differed per year due to varying weather conditions, with an average of an additional 16 kg N ha^{-1} $year^{-1}$ (range −14 to 45) compared to 2020. When moving to the target HW groundwater table, SNS reduced on average by 13% compared to the target LW groundwater table (average of 245 and 282 kg N ha^{-1} $year^{-1}$ for HW and LW, respectively). Decreased SNS with higher groundwater tables can explain the lower DMY, since the wetter conditions can lower the mineralisation rate (Pijlman *et al.*, 2020).

Our findings are at plot level, and show the potential obtainable productivity with higher groundwater tables. This excludes losses that occur during grazing, trampling by cows or trafficking by machinery. Furthermore, the lower load bearing capacity in wetter conditions can result in delayed timing of harvesting and fertilisation (Janssen *et al.*, 2023). These additional losses can impede realizable grass yield and quality, which in turn affects milk production and farm economy. Nonetheless, our findings show that average predicted DMY with higher groundwater tables can still be considered productive (11 Mg DM ha^{-1} $year^{-1}$ with 125 kg N ha^{-1} $year^{-1}$). Since raising groundwater tables is an important practice to achieve the goals set in the Climate Agreement, farmers should be encouraged to implement the practice on their farms. However, the associated losses should be compensated to incentivise farmers to transition towards farming with higher groundwater tables. Alternatively, new business models could be designed that value farms not only for milk production, but for peat conservation as well.

Conclusions

In conclusion, DMY and SNS were both affected by groundwater table and varied during the study years. The observed reduction in DMY with higher groundwater tables could partly be explained by the reduced SNS due to lower mineralisation rates in wetter conditions. While the predicted reductions with increased groundwater tables were on plot level, which exclude potential losses on farm level, they nonetheless show that pasture productivity can be maintained. To encourage raising groundwater tables on dairy farms, the consequences of higher groundwater tables on farm level should be further explored.

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