Rising atmospheric CO2 concentrations globally affect photosynthesis of peat-forming mosses

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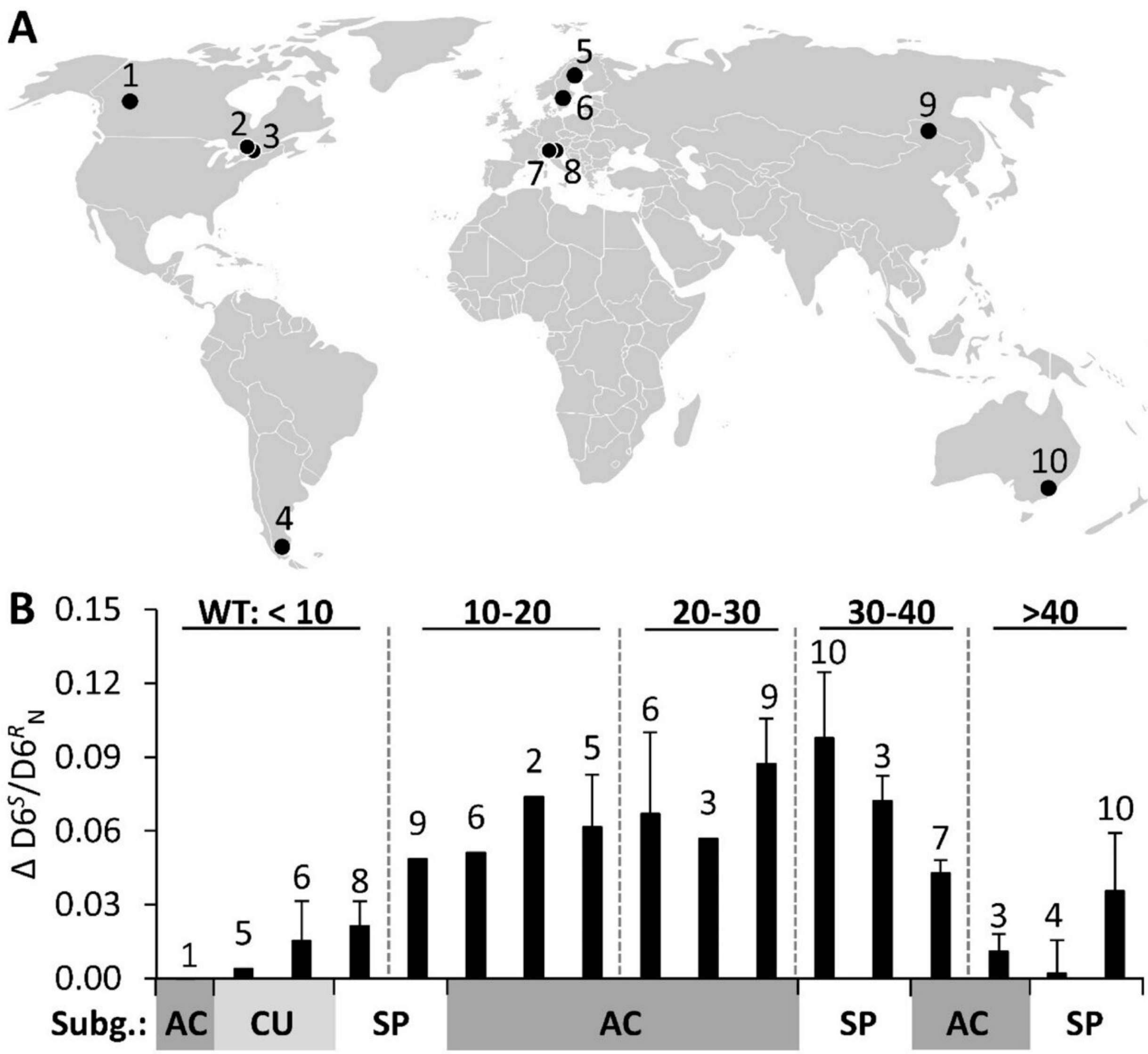

Global changes in the deuterium isotopomer ratio ($\Delta D6^S/D6^R{}_N$) of Sphagnum during the twentieth century representing changes in the photorespiration to photosynthesis ratio. (A) Global distribution of investigated sites. (B) Response of the $D6^S/D6^R$ ratio per unit change in 1000/[CO_2] between modern and historical Sphagnum samples ($\Delta D6^S/D6^R{}_N$). Five water table depths (WT) categories (in cm) are indicated by vertical dashed lines. Sphagnum subgenera are indicated on the x-axis by gray/white shading: AC, ACUTIFOLIA (dark gray); CU, CUSPIDATA (light gray); SP, SPHAGNUM (white). Error bars indicate standard error, n = 1–4 (see Table S1 for more information). Numbers above error bars correspond to sample sites as numbered in (A). Credit: DOI: 10.1038/s41598-021-02953-1

Scientists at Umeå University and Swedish University of Agricultural Sciences have developed ways to decipher effects of the CO_2 rise during the past 100 years on metabolic fluxes of the key plant species in peatlands, mosses. Analyses of cellulose in peat cores collected by collaborating scientists working in five continents indicate that a CO_2-driven increase in photosynthesis of mosses is strongly dependent on the water table, which may change the species composition of peat moss communities.

As human CO_2 emissions continue, it is increasingly important to capture CO_2 to mitigate the associated climate change. Peatlands are the largest soil carbon stores globally, but the impact of climate change on peatlands is still unknown. During the 20th century, global atmospheric CO_2 concentrations have increased by nearly 50 percent and further increases are inevitable according to the Intergovernmental Panel on Climate Change, IPCC, with severe consequences for humanity. So far, uptake of CO_2 by the land biosphere has dampened the CO_2 rise and prevented even more severe effects.

Although peatlands cover only three percent of the global land surface, they store a third of the global soil carbon. Thus, uptake of CO_2 by peat mosses is important, but little is known about how their physiology is affected by rising CO_2 levels. To understand if peatlands will keep storing carbon and mitigate climate change in the future, the scientists investigated peat mosses' responses to the increase in atmospheric CO_2.

For the study, collaborating researchers from five continents collected peat cores from ten locations worldwide. In a novel use of nuclear magnetic resonance pectroscopy, distributions of the stable hydrogen isotope deuterium in cellulose of modern and century-old peat mosses were then compared. This allowed us to reconstruct changes in photosynthetic efficiency during the 20th century, by estimating the impact of photorespiration, a side reaction of photosynthesis.

"Photorespiration is critical for the carbon balance of plants because it reduces the efficiency of photosynthesis by up to 35 percent, and it is suppressed by increasing CO_2 but accelerated by increasing temperature," says Jürgen Schleucher, Professor at Department of Medical Biochemistry and Biophysics at Umeå University, Sweden.

The analysis revealed that increasing CO_2 during the last 100 years has reduced photorespiration, which has probably boosted carbon storage in peatlands to date and dampened climate change. However, increasing atmospheric CO_2 only reduced photorespiration in peatlands when water levels were intermediate, not when conditions were too wet or too dry. Unlike higher plants, mosses cannot transport water, so the water table level controls their moisture content, which affects their photosynthetic performance. So, models based on higher plants' physiological responses cannot be applied.

That the effect of CO_2 depends on the water table level can have major consequences for peatland species composition, as only mosses that grow at an intermediate distance from the water table level benefit from the higher atmospheric CO_2 concentration. Moreover, changes in the peatlands' water balance can strongly affect their future carbon balance as too wet or too dry conditions reduce peat mosses' ability to scavenge carbon.

Although peatlands have dampened CO_2-driven climate change so far, the changes have already had devastating effects. If human CO_2 emissions are not strongly reduced, the atmospheric CO_2 concentration will further increase by hundreds of ppm by 2100, and average global temperatures will rise several degrees C above pre-industrial levels. It is unclear how peatlands will be affected by this.

"To get a clearer picture of photorespiration's importance for peat mosses and peat carbon accumulation, the next step is to transfer our data into tailored photosynthesis models to estimate global peatland carbon fluxes. Future CO_2 levels, temperature rises, changes in precipitation and water table levels will all need to be considered to forecast peatlands' fate in a changing climate," says Jürgen Schleucher.

The study has been published in *Scientific Reports*.

More information: Henrik Serk et al, Global CO2 fertilization of Sphagnum peat mosses via suppression of photorespiration during the twentieth century, *Scientific Reports* (2021). DOI: 10.1038/s41598-021-02953-1

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