Insights into moss growth under elevated carbon dioxide levels may benefit climate change models

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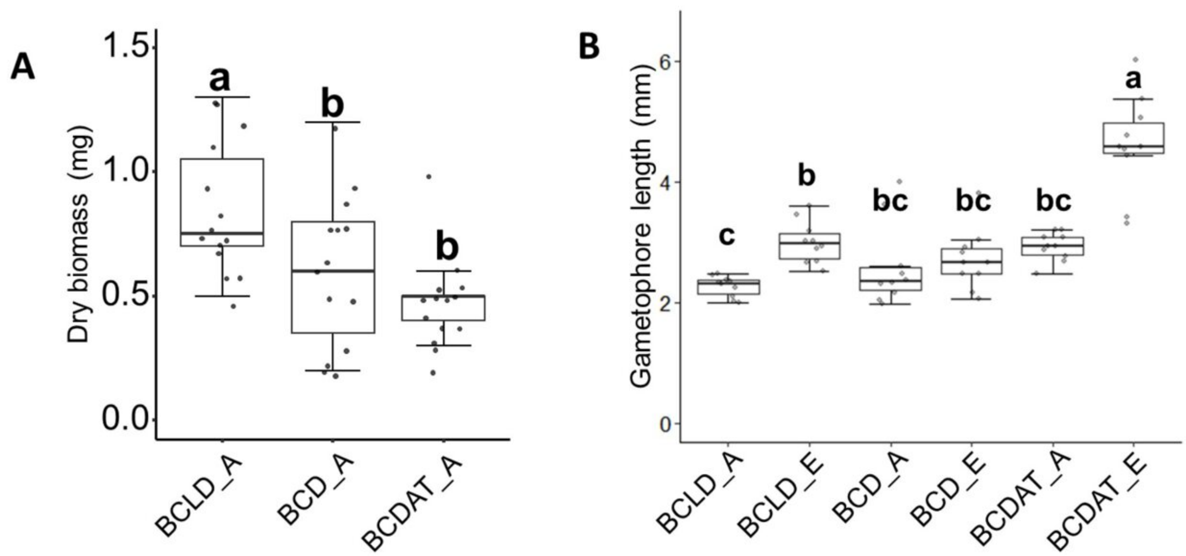

Modulation of gametophore-related phenotypes of Physcomitrium patens by elevated CO_2 and nitrogen availability. A) Dry weight of five-week-old gametophytes grown on low (BCLD), medium (BCD), or high nitrogen (BCDAT) media showing the effect of nitrogen on P. patens growth (n = 14 gametophytes). B) Gametophore lengths of five-week-old gametophytes of P. patens grown in different nitrogen supplementation under ambient (A; ~400 ppm) or elevated (E; 1000 ppm) CO_2 conditions (n = 10 gametophores). All statistical analyses are done with one-way ANOVA followed by Tukey's test. Statistically significant differences between treatments are marked with lowercase letters. The upper and lower whiskers follow Tukey's style, marking the closest data point within the 1.5× interquartile range above the first and below the third quartile. The horizontal line points to the median. Credit: *New Phytologist* (2023). DOI: 10.1111/nph.19348

Approximately 12,000 species of mosses exist and cover close to 4 million square miles of earth, equivalent to the size of Canada, and are ecologically and evolutionarily important. Mosses play an essential role in rainwater retention, decreasing plant pathogens and increasing carbon sequestration in soil, thus improving the overall soil health.

Mosses also protect long-term carbon storage systems, such as bogs and permafrost. Moss growth is increasingly used in models to improve the accuracy of climate change predictions. However, the impact of key climate variables such as elevated CO_2 (eCO2) levels on mosses remains underexplored.

Mosses experience eCO_2 levels differently than most land plants. Being small, they grow close to the soil surface, and are exposed to CO_2 released due to decomposition of soil organic matter. Thus, mosses are likely exposed to considerably higher CO_2 levels than most other plants.

Unlike flowering plants, mosses do not use stomata for CO_2 entry and therefore may have less access to the available CO_2. Consequently, how mosses will respond to eCO_2, whether they will benefit from eCO_2 and the extent to which their response will differ from other land plants posed important and interesting questions.

A collaborative research team from the Pandey and Allen labs at the Donald Danforth Plant Science Danforth Center addressed these questions and demonstrated that the model moss Physcomitrium patens (P. patens) gains three-fold more biomass in elevated CO_2 conditions by adjusting its growth, metabolism and physiology.

Their work, Physcomitrium patens response to elevated CO_2 is flexible and determined by and interaction between sugar and nitrogen availability, was recently published in *New Phytologist*. Their results demonstrated that the increase in biomass was due to improved photosynthesis and a delicate balancing of life cycle transition between diffuse and profuse growth depending on nitrogen and carbon availability.

"Mosses are the major vegetation sustaining natural long-term carbon storage systems like permafrost and bogs. Moss-cover over the permafrost insulates them from direct sunlight and avoid thawing. In bog ecosystems, Sphagnum mosses has been providing conditions suitable for sequestering carbon for several millenniums. So, mosses are pertinent to the actions on today's climate emergency," said the lead author of the study, Boominathan Mohanasundaram, Ph.D., post-doctoral scientist in the Pandey laboratory.

This study relied on the state-of-the-art core facilities at the Danforth Center, including the Mass Spectrometry and Proteomics and Plant Growth facilities. "The capacity to produce impactful, rigorous science comes from leveraging the expertise and instrumentation available here at the Center," noted Somnath Koley, Ph.D., research scientist in the Allen USDA-Agriculture Research Service Laboratory and a key collaborator.

This research offers a framework for comparing the eCO_2 responses of P. patens with other plant groups. This research project is a part of the larger program supported by NSF Rules of Life program that aims to decipher epigenetic inheritance mechanism of eCO2 responses across a broad range of plants.

The current research also provides crucial insights into moss growth that may benefit climate change models. Although further studies are needed to evaluate the growth of other important moss classes with disparate ecological niches to assess the generality of the observed metabolic features, our results suggest that the eCO_2 environment will likely enhance moss biomass accumulation and could reduce solar heat transfer to the soil to prevent the thawing of permafrost.

Extending the insights from this study to the survival, spread, and carbon assimilation capacity of mosses across a range of soil nitrogen and CO_2 regimes will certainly help our understanding of how this important group of plants respond to the projected climate change in the future.

More information: Boominathan Mohanasundaram et al, Physcomitrium patens response to elevated CO_2 is flexible and determined by an interaction between sugar and nitrogen availability, *New Phytologist* (2023). DOI: 10.1111/nph.19348

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