Antagonism between elevated CO2, nighttime warming, and summer drought reduces the robustness of PSII performance to freezing events - DTU Orbit (21/12/2018)

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Plant responses to warming, elevated CO2, and changes in summer precipitation patterns involve complex interactions. In this study we aim to reveal the single factor responses and their interactive effects on photosystem II (PSII) performance during an autumn-to-winter period. The study was carried out in the CLIMAITE multifactor experiment, which includes the combined impact of elevated CO2 (free air carbon enrichment; CO2), warming (passive nighttime warming; T) and summer drought (rain-excluding curtains; D) in a temperate heath ecosystem. PSII performance was probed by the effective quantum yield in light, Fv′/Fm′, using the pulse amplitude methodology, and the total performance index, PItotal, which integrate changes of the chlorophyll-a fluorescence transient including the maximal quantum yield in darkness, Fv/Fm. Decreasing temperature during autumn linearly reduced PItotal, both in the wavy hair-grass, Deschampsia flexuosa, and in the evergreen dwarf shrub common heather, Calluna vulgaris, and following freezing events the PItotal and Fv′/Fm′ were reduced even more. Contrary to expected, indirect effects of the previous summer drought reduced PSII performance before freezing events, particularly in Calluna. In combinations with elevated CO2 interactive effects with drought, D×CO2 and warming, T×D×CO2, were negatively skewed and caused the reduction of PSII performance in both species after occurrence of freezing events. Neither passive nighttime warming nor elevated CO2 as single factors reduced PSII performance via incomplete cold hardening as hypothesized. Instead, the passive nighttime warming strongly increased PSII performance, especially after freezing events, and when combined with elevated CO2 a strongly skewed positive T×CO2 interactive effect was seen. This indicates that these plants take advantage of the longer growing season induced by the warming in elevated CO2 until a winter frost period becomes permanent. However, if previously exposed to summer drought this positive effect reverses via interactive D×CO2 and T×D×CO2 effects immediately after freezing events, causing the full combination of TDCO2 not to differ from the control. In a future warmer climate with high CO2 and summer drought, the occurrence of freezing events thus seem highly decisive for reducing PSII performance in the autumn-to-winter period. Such a reduced robustness of PSII performance may be highly decisive for the magnitude of the late season photosynthetic carbon uptake and reduce the growing season length in these temperate heath plants.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Ecosystems Programme, University of Copenhagen
Contributors: Albert, K. R., Boesgaard, K. S., Ro-Poulsen, H., Mikkelsen, T. N., Andersen, S., Pilegaard, K.
Pages: 1-12
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Environmental and Experimental Botany
Volume: 93
ISSN (Print): 0098-8472
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.39 SJR 1.376 SNIP 1.574
Web of Science (2017): Impact factor 3.666
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.75 SJR 1.491 SNIP 1.804
Web of Science (2016): Impact factor 4.369
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.82 SJR 1.34 SNIP 1.714
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 3.5 SJR 1.138 SNIP 1.873
Web of Science (2014): Impact factor 3.359
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.4 SJR 1.09 SNIP 1.585
Web of Science (2013): Impact factor 3.003
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.38 SJR 1.137 SNIP 1.943
Web of Science (2012): Impact factor 2.578
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 3.4 SJR 1.079 SNIP 1.847
Web of Science (2011): Impact factor 2.985
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.46 SNIP 1.914
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.169 SNIP 1.996
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.963 SNIP 1.518
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.796 SNIP 1.13
Scopus rating (2006): SJR 0.827 SNIP 1.497
Scopus rating (2005): SJR 0.773 SNIP 1.424
Scopus rating (2004): SJR 0.84 SNIP 1.399
Scopus rating (2003): SJR 0.644 SNIP 1.12
Scopus rating (2002): SJR 0.516 SNIP 1.166
Scopus rating (2001): SJR 0.485 SNIP 0.785
Scopus rating (2000): SJR 0.286 SNIP 0.569
Scopus rating (1999): SJR 0.295 SNIP 0.511
Original language: English
Keywords: Cold hardening, CLIMAITE, Chlorophyll fluorescence, Calluna, Deschampsia
DOIs:
10.1016/j.envexpbot.2013.03.008
Source: dtu
Source-ID: n::oai:DTIC-ART:elsevier/389531377::30396
Research output: Research - peer-review | Journal article – Annual report year: 2013