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Plant eco-physiological response patterns to summer drought, elevated CO$_2$ and warming in a semi-natural temperate heath ecosystem

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Plant eco-physiological responses to multiple environmental changes are being studied in a temperate semi-natural heath ecosystem according to a realistic Danish climatic scenario anno 2075. Since direction of ecosystem responses can not be deduced from single factor experiments alone this necessitates the multi-factor approach. The environmental treatments are elevated level of CO$_2$ (FACE 510 ppm, [CO2]), passive nighttime warming (IR-reflective curtains, [T]) and summer drought (rain activated curtains, [D]) and started in Oct. 2005. Leaf level carbon input and water consumption through photosynthesis were measured by gas exchange techniques on Common Heather (Calluna vulgaris) and Hair Grass (Deschampsia flexuosa). Parallel measurements of chlorophyll-flourescence, xylem water potential, leaf carbon and nitrogen content were conducted. In summer 2007, [D] decreased plant available soil water led to significantly lower plant water potential compared to controls, whereas [CO2] and [T] had no effect. The plant water potential was 2-3 times lower in the deep rooted woody shrub C. vulgaris compared to the grass D. flexuosa. No visual symptoms of drought stress were seen for C. vulgaris, but part of D. flexuosa had senescent leaves. For both species no effects on maximal carboxylation velocity, $V_{c_{\text{max}}}$, and maximum rate of electron transport, $J_{\text{max}}$, were seen, but for D. flexuosa [D] increased day time respiration, $R_d$, was found. Despite small impact on photosynthetic parameters $V_{c_{\text{max}}}$ and $J_{\text{max}}$ we observed a significantly decreased maximal photosynthesis in [D] for both species. Under field conditions the transpiration rates were significantly lowered by [D], but [CO2] and [T] had no effect. Interactions between [D*CO2] and [T*D*CO2] showed lower transpiration rates than expected whereas [T*CO2] were higher for C. vulgaris. Parallel responses were seen for values of stomatal conductance. These responses indicate the strong impact of [D] linking low water availability to decreased plant water potential and water consumption via transpiration. Further, the [D] also decreased the net photosynthesis for both species, while [CO2] had the opposite effect. In combination this led to a significantly higher Water Use Efficiency in [CO2]. The increased carbon uptake increased the leaf C/N ratio through a marginal, but significant, C% decrease and a stronger N% decrease in [CO2]. These issues of the contrasting response patterns could not be deduced from single factor studies alone and adds to the importance of long term multifactor studies.