Long-term ecophysiological responses to climate change

Plant physiology is affected by climate change. Acclimations of photosynthetic processes are induced by short-term changes in climatic conditions. Further acclimation can be caused by long-term adjustments to climate change due to ecosystem-feedbacks. The aim of this PhD was to investigate plant physiological responses to climate change in a seasonal and long-term perspective.

The effects of elevated CO₂, passive night time warming and periodic summer drought as single factor and in combination, on plant physiology were investigated in the long-term multifactorial field experiment CLIMAITE in a Danish heathland (www.climaite.dk). The responses of plant physiological parameters, such as photosynthetic capacity, stomatal conductance and respiration were measured after six years of treatments.

A small leaf adaptor frame was developed to conduct high precision leaf gas exchange measurement in the field (Paper I). The leaf adaptor frame increased the precision of the commonly used leaf gas exchange method. It was used to conduct all physiological measurements on the two dominated heathland species at the CLIMAITE-site, the grass Deschampsia flexuosa and the shrub Calluna vulgaris.

In Calluna, differences in magnitude of physiological responses to the climate change treatment were found between warm and cold season. In the warm season no down-regulation of the photosynthetic capacity under elevated CO₂ was found. Opposite significantly down-regulated photosynthetic capacity was observed during the cold season. However, in both seasons the stimulation of photosynthesis was maintained in elevated CO₂. No effect of warming was found in either of the seasons, but drought was found to counterbalance the CO₂-induced stimulation of photosynthesis during warm season (Paper II).

Besides the study of seasonality, long term responses of plant physiology to the climate change factors were investigated. In the CLIMAITE-experiment it has been shown that 2 years of treatment altered physiological responses in Deschampsia and Calluna. In the work of this PhD similar responses were observed after 6 years of treatment. The magnitudes of physiological responses were related to differences in soil water content in the respective years. Elevated CO₂ was the main driver for physiological changes in the two species with different growth strategies. The growth strategies of Deschampsia and Calluna defined the physiological responses to elevated CO₂ and only severe drought was observed to change the magnitude of responses (Paper III).

In conclusion, the leaf adaptor frame greatly improved the measurement precision of leaf gas exchange. High precision photosynthetic measurements showed that leaf level responses to climate change factors are stable upon a wide range of seasonal and inter-annual variation. Long-term ecosystem adjustments after 6 years of treatments did not cause further physiological acclimation in either Deschampsia or Calluna. The study indicates robustness of the Danish heathland ecosystem to moderate climate change.

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