Thallus dehydration effects and physiological consequences in Antarctic lichens: Case study from the King George Island, Antarctica

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Keywords: desiccation, chlorophyll fluorescence, effective quantum yield

INTRODUCTION

In this study, we combined two approaches: (1) Field study of dehydration-induced reduction of primary photosynthetic processes in lichen *Placopsis antarctica*, and (2) Laboratory-based study on critical hydration causing full inhibition of the processes in two lichen species, one having crustose (*P. antarctica*), and the other one fruticose thallus (*Ramalina terebrata*).

MATERIAL AND METHODS

Field experiment was conducted on thalli of *P. antarctica.* The lichens were grown in open top chambers (OTCs) installed at the Fildes Peninsula, La Cruz Plateau (King George Island) for one year. After the1-year-long growth, primary photochemical processes of photosynthesis were measured by *in situ* chlorophyll fluorescence monitoring during austral summer season 2019. For such purpose, a multichannel monitoring fluorometer Moni-PAM (Heinz Walz, Germany) was used to measure diurnal courses of the effective quantum yield of photochemical processes in photosystem II (Φ_{PSII}), as well as thallus temperature and incident photosynthetically-active radiation (PAR). The Φ_{PSII} values were used for the calculation of photosynthetic electron transport rate (ETR = $0.5 \times 0.84 \times PAR \times \Phi_{PSII}$). Then, ETR was plotted against time (13 days of the measurements) and PAR, and analyzed.

Laboratory experiments comprised the measurements of dehydration-response curves of chlorophyll fluorescence parameters recorded by a chlorophyll fluorescence imaging (ChFI) using a FluorCam (PSI, CZ). The method of slow Kautsky kinetics supplemented with saturation pulses in dark- and light-adapted state was used. For analysis, effective quantum yield of photosynthetic processes in PSII (Φ_{PSII}) and steady-state chlorophyll fluorescence (F_S) were selected. On the Φ_{PSII} and F_S dehydration-response curves, critical points were distinguished. The critical points denoted the relative water contents (RWCs) at which the parameter started to be limited (C1) and dropped to 0 (C2).

RESULTS AND DISCUSSION

In OTC-located *P. antarctica* thalli, ETR was found hydration-limited. This was particularly valid for sunny and semicloudy days with PAR values above 100 μmol m^{-2} s^{-1}.

Maximum ETR at such situations varied between 25 and 40. In control *P. antarctica* (ouside OTCs) much higher ETR values were reached (100-200). ETR in control *P. antarctica*, thanks to sufficient thallus hydration, increased linearly with PAR increase. OTC-located thalli were partial dehydrated and showed more or less constant ETR values of about 40 at the PAR above 100 μmol m^{-2} s^{-1}. Such finding suggest that OTC-located thalli, compared to the outside control ones, may have lower rate of primary and secondary photosynthetic processes in algal parts during a day and/or vegetation season.

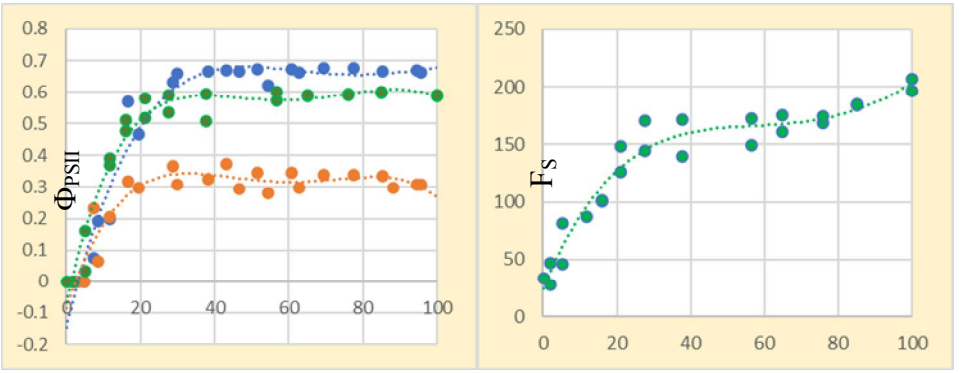

Fig. 1. Dehydratation-response curve of effective quantum yiled of photosynthetic processes in PSII (Φ_{PSII}) - left, and steady-state chlorophyll fluorescence (F_S) - right. The curves were recorded for *P. antarctica* (blue - algal part, orange - cyanobacterial cephalodium), and *R. terebrata* (green) in a laboratory experiment.

Desiccation of thalli led to the decrease in Φ_{PSII} (Fig. 1). With the decline from fully wet (relative water content, RWC of 100%) to semidry state (RWC of about 30%, C1=30%), Φ_{PSII} showed no change with dehydration in both species. However, much higher Φ_{PSII} was found for the algal part of *P. antarctica* and thalli of *R. terebrata,* than for cephalodium in *P. antarctica*. With pronounced desiccation (RWC decrease from 40 to 3%, C2 of about 3%), a rapid decline to full inhibion of Φ_{PSII} (at RWC=0%) was apparent. The decline rate was comparable in both species. The C2 RWC was, however, found a bit higher in *P. antarctiac* than *R. terebrata.*

Both species showed a high resistance to dehydration. With dehydration, F_S declined in a polyphasic manner and showed C1 at about 30% RWC. In the RWC range from 30 to 0%, decline in F_S was more rapid than at higher thallus hydration. In *R. terebrata* Φ_{PSII} was well related to F_S (R^2=0.92), which indicated a high potential of the F_S signal to monitor vigor of lichen thalli and their photosynthetic activity.

***Acknowledgements*:**
The authors thank the following projects: INACH RT2716, FONDECYT 1181745, CzechPolar-II (LM2015078), and ECOPOLARIS (CZ.02.1.01/0.0/0.0/16_013/0001708).