Seasonal dynamics of **photosynthetic and N_2-fixation activity of cyanobacterium *Nostoc commune*** s. l. in wet hummock tundra (Central Svalbard, High Arctic)

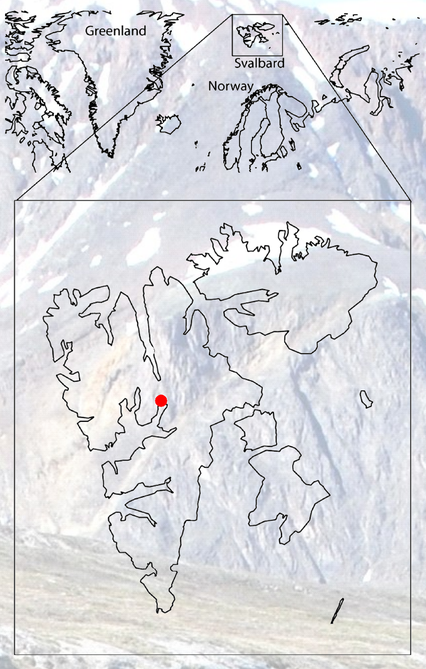
Tomáš Hájek[1,2], Jana Kvíderová[1], Josef Elster[1,2] and Miloslav Šimek[2,3]

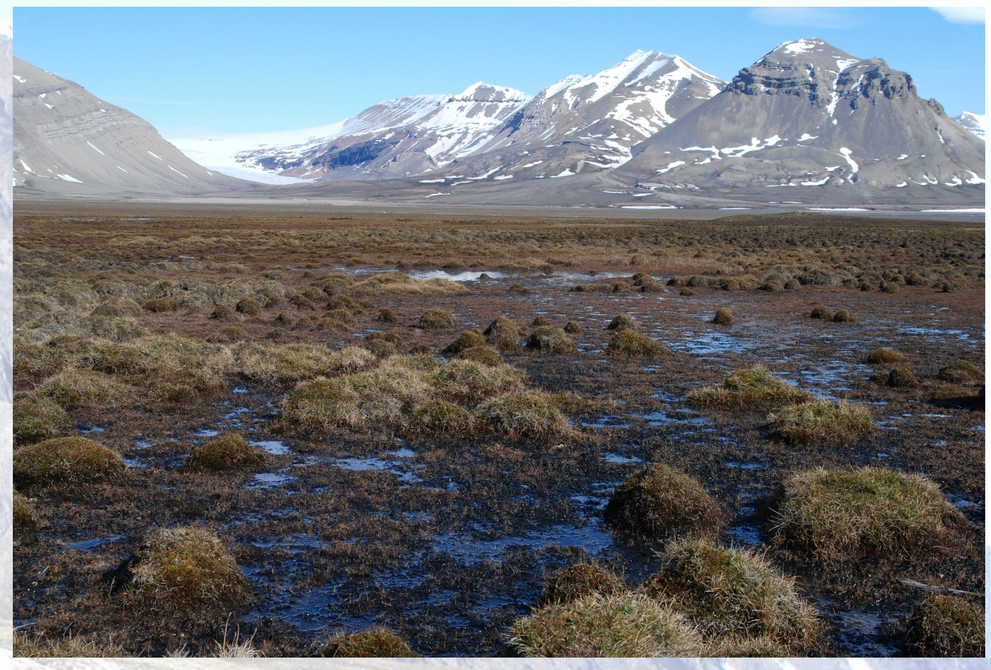
[1]Institute of Botany AS CR, Třeboň, Czech Republic; [2]University of South Bohemia, Faculty of Science, České Budějovice, Czech Republic; [3]Institute of Soil Biology, Biology Centre AS CR, České Budějovice, Czech Republic

Introduction

Wet hummock tundra in Petuniabukta (Billefjorden, Central Svalbard) is diverse and productive habitat that serves as important source of food for herbivores in the local terrestrial ecosystem. The cyanobacterium *Nostoc commune* produces high biomass in wet hummock tundra microhabitats, forming macroscopic colonies of filaments embedded in extracellular polysaccharides.

In the Arctic, cyanobacteria play a key role in nitrogen cycling due to their nitrogenase activity allowing fixation of N_2, which affects also the ecosystem primary production and carbon cycle. Moisture and irradiance represent the most important ecological factors influencing the cyanobacterial physiological activity.





Nostoc colony (real size)

How the physiological activity of *Nostoc* colonies respond to seasonal fluctuation in light intensity and water availability?

Colonies of *Nostoc commune* are highly desiccation tolerant and possess efficient photoprotective pigments.

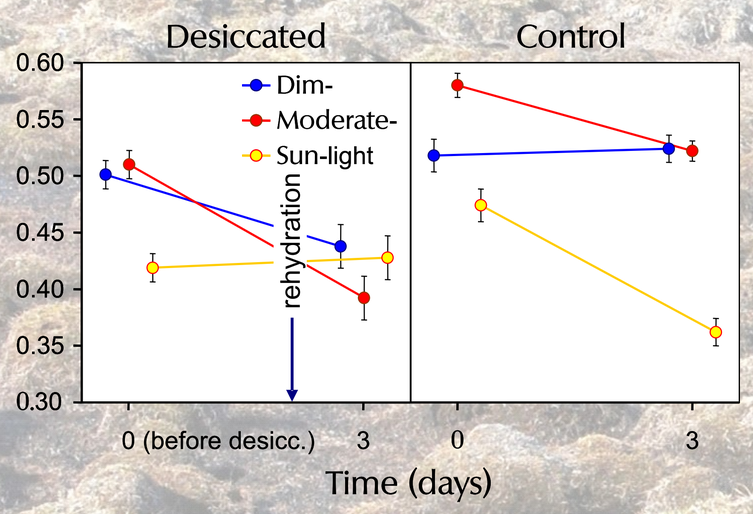
Methods

We assessed the effects of light intensity and desiccation in *Nostoc* colonies by:
- nitrogenase activity – estimated by acetylene reduction assay (ethylene production);
- photosynthetic activity – estimated by chlorophyll fluorescence using an imaging fluorometer; quantum yield of PSII (Φ_{PSII}) measured at 100 µmol of PAR m^{-2} s^{-1}.

We tested 3 light levels (dim, moderate, sun; i.e. 50, 200, 900 µmol of PAR m^{-2} s^{-1}).
The colonies were desiccated for 2 days and measured 1 day after rehydration.
The measurements were done under field conditions in summer (July) and autumn (September; already without sun light level), 2010.

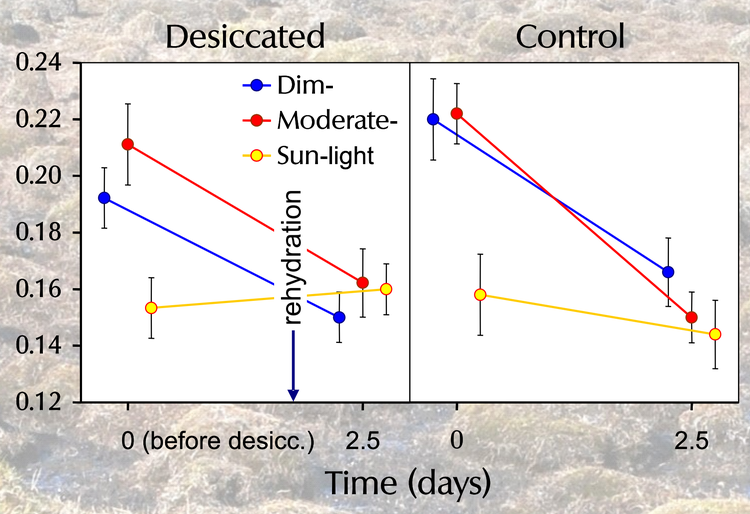
Results (only summer results presented in graphs; means ± s.e. shown)

Photosynthetic activity – F_v/F_m



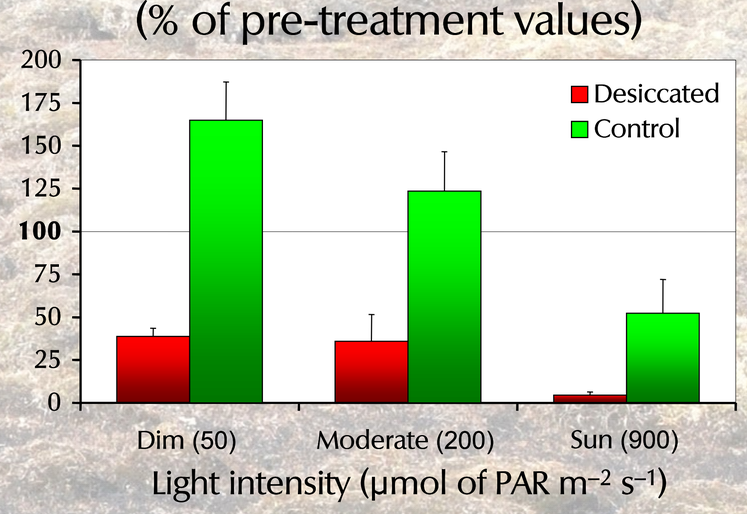
F_v/F_m indicates (= decreases after) light stress
- already lowest in sun-collected samples;
- in the sun, it decreased in control (non-desiccated) samples, indicating protective effect of desiccation against sunlight damage (statistically significant interaction *Desiccation * Light * Time*);
- in autumn, it was significantly reduced already in moderate light irrespective of desiccation.

Photosynthetic activity – Φ_{PSII}



Φ_{PSII} is a predictor of photosynthesis
- already lowest in sun-collected samples
- was not affected by the desiccation

Nitrogenase activity (% of pre-treatment values)



Nitrogenase activity (indicates N-fixation rate)
- was inhibited even by moderate light when compared with dim light;
- was inhibited by desiccation in all lights;
- was reduced to 5% after sun desiccation (significant interaction *Desiccation * Light*);
- was reduced 30 times in autumn in non-desiccated controls (mean values1500 vs. 50 nmol C_2H_4 h^{-1} g^{-1} dry mass);
- was fully lost in several desiccated samples in autumn (irrespective of light intensity).

In general, direct sunshine reduced PSII and nitrogenase activity in both, non-desiccated controls and notably after short desiccation.

Field-collected non-desiccated samples:
- lack any general relationship between PSII and nitrogenase activity
- showed very strong seasonal variation in nitrogenase activity (autumn samples have already experienced freezing–thawing periods that might be a reason for that – DuBois *et al.* 1983)

In summary, summer sunshine leads to desiccation and also to light stress in *Nostoc* colonies. It results in attenuation of their nitrogenase activity. On the other hand, late-season conditions showed even stronger inhibitory effect. Thus, early-summer conditions (still moist and already warm) are probably most suitable for the biological nitrogen fixation in the Arctic wet hummock tundra ecosystem.

INSTITUTE OF BOTANY ASCR, Zámek 1, CZ-252 43 Průhonice, Czech Republic
Tel: +420 271 015 233 Fax: +420 271 015 015 www.ibot.cas.cz