Photoinhibition of primary photosynthetic processes in *Polytrichum commune*: Analysis of driving factors affecting species resistance

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INTRODUCTION

Photoinhibition of photosynthesis is well-known phenomenon in higher plants. In mosses, photoinhibition happens especially in shade-adapted species, when they are exposed to high light doses (*e.g.* Murray et al. 1993, Hájek et al. 2009). Photoinhibition of chloroplastic primary processes of thotosyntehsis happens when light intensity exceeds the capacity/activity of the photosynthetic electron transport chain in chloroplastic apparatus. Such situation leads to inactivation and damage of the photosynthetic apparatus, photosystem II (PSII) in particular.

Mosses from sunny habitats are considered photoinhibition tolerant because their photosynthetic apparatus has photoprotective mechanisms of vascular plants and green algae. Mosses possess "vascular plant-type" light-harvesting complex protein PsbS and "algal-type" light-harvesting complex stress-related protein (LHCSR). In mosses, LHCSR and PsbS may migrate between PSII and PSI in order to quench excitation energy (Furukawa et al. 2019). Recent studies (*e.g.* Dikaios et al. 2019) confirmed the role of LHCSR proteins in thermal dissipation in photoinhibited mosses. The two proteins are involved into non-photochemical quenching of absorbed light energy, *i.e.*, they protect PSII from overenergization photooxidation of PSII components.

In the study, resistence of *P. commune* has been investigated by chlorophyll fluorescence. Slow Kautsky kinetics supplemented with the analysis of quenching mechanism was applied. The hypothesis of medium to high resistence of the species was tested since the species was taken for laboratory analysis from treeless, open, sunny alpine environment.

MATERIAL AND METHODS

Polytrichum commune was collected in the Jeseníky Mts (50.08637 N, 17.23079 E). In locality Tabulové skály rocks, (1 415 m a. s. l.). After transfer to a laboratory, they were sprayed regularly by distilled water to reach optimum hydration. Then, *P. commune* was exposed to three different photoinhibitory treatments (PIT): (1) 1 500 μmol m^{-2} s^{-1} of photosynthetically-ative radiation (PAR) for 60 min., (2) 1 200 μmol m^{-2} s^{-1} for 60 min., and (3) 1 200 μmol m^{-2} s^{-1} for 30 min. Before the PIT, immediately after the PIT and, consequently, during recovery, chlorophyll fluorescence parameters were measured by a Handy Fluorcam HFC-010 (Photon Systems Instruments, Czech Republic). Potential (F_V/F_M) and effective quuantum yield (Φ_{PSII}) of photochemical processes in photosystem II (PSII) were measured, as well as non-photochemical quenching (qN).

RESULTS AND DISCUSSION

The PIT induced a decrease in F_V/F_M and Φ_{PSII}. The decrease found immediately after the PIT was dose dependent. Most pronounced minimum was found for the treatment 1

(*i.e.* 1 500 µmol m^{-2} s^{-1} PAR) for 60 min.: 0.58 and 0.48 for F_V/F_M and Φ_{PSII}, respectively. Then, during recovery time, an increase in F_V/F_M and Φ_{PSII} was found. The increase was faster and getting towards the pre-photoinhibitory values rather in F_V/F_M than Φ_{PSII}. Recovery of Φ_{PSII} remained uncompleted even after 3 h of recovery time. For in F_V/F_M, two phases of recovery were distinguished (the fast found after 20 min. of recory, and slow found later). For Φ_{PSII}, the two phases were not distinguished. Non-photochemical quenching showed a PIT dose-dependent increase and slow, uncompleated recovery during the 3-h-lasting recovery. Non-photochemical quenching (qN), when plotted against Φ_{PSII}, showed more or less linear relation for the data recorded immediately after the PIT and during recovery. Absolute qN values were dose-dependent (*see* Fig. 1).

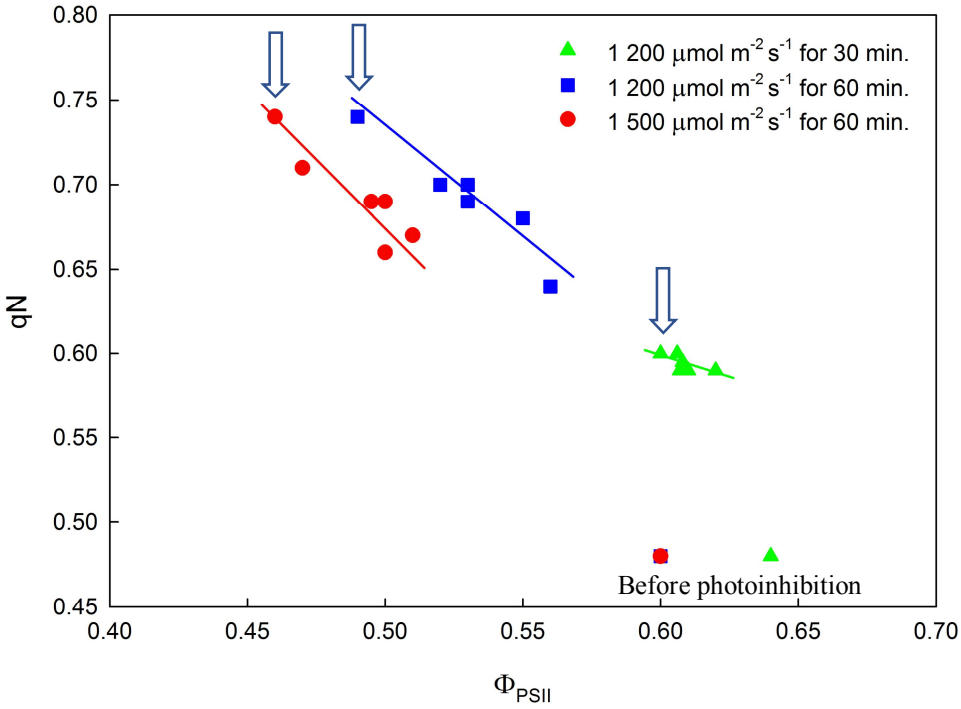

Fig. 1. Relation of non-photochemical quenching (qN, dependent variable) to effective quantum yield of PSII (Φ_{PSII}) in *Polytrichum commune* exposed to particular photoinhibitory treatments: 1 500 µmol m^{-2} $s^{-1}$of PAR) for 60 min. (red symbols), 1 200 µmol m^{-2} s^{-1} PAR for 60 min. (blue symbols), and 1 200 µmol m^{-2} s^{-1} PAR for 30 min (green symbols). The qN values recorded immediately after the photoinhibitory treatments are indicated by the arrows.

CONCLUSION

Polytrichum commune could be considered relatively resistant to photoinhibition since it showed effective recovery of F_V/F_M and Φ_{PSII} when exposed to 1 200 µmol m^{-2} s^{-1} for 30 and 60 min. Since uncompleted recovery was found, more apparently for Φ_{PSII}, when *P. commune* was exposed to 1500 µmol m^{-2} s^{-1} for 30 min., the species might be ranked among relatively resistant. Supporting item is that non-photochemical quenching (qN) did not fully recovered from the peak values recorded immediately after the PIT ever after 3 h of recovery. It indicates that photoprotective mechanisms remained active even during the recovery time.

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