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Photosynthetic response and DNA mutation of tropical, temperate and polar *Chlorella* under short-term UVR stress

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ABSTRACT

Changes in photosynthetic efficiency of Photosystem II can be used as an early stress indicator in phototrophs. In this study, chlorophyll fluorescence, measured by a Pulse-Amplitude Modulated Fluorometer (PAM), was used to determine the photosynthetic performance of tropical, temperate, Antarctic and Arctic *Chlorella* in response to short-term acute ultraviolet radiation (UVR) stress, with measurements of maximum quantum yield (Fv/Fm), photosynthetic efficiency (α), maximum electron transport rate (rETRm) and photoadaptive index (E_k). Three light treatments were conducted over a continuous, five-hour duration: (i) control subjected only to photosynthetic active radiation (PAR), (ii) PAR + UVA (UVA) and (iii) PAR + UVA + UVB (UVR). Tropical *Chlorella* showed better adaptive ability to UVA stress compared to strains from temperate and polar regions. UVB stress caused significant photosynthetic dysfunction in all samples, with polar strains showing a lower inhibition (about 40%) compared to the tropical strain (about 98%). Photosynthetic responses in *Chlorella* towards UVR are possibly origin dependent. DNA mutation induced by both UVA and UVR treatments was revealed by Random Amplified Polymorphic DNA (RAPD) analysis. Out of sixty RAPD primers tested, two primers: S33 (polymorphism degree 44.83%) and S90 (polymorphism degree 38.71%) were chosen as potential primers to conduct genomic study of UV stress in microalgae.

1. Introduction

The level of ultraviolet radiation (UVR) is higher in the tropics than in polar and temperate regions, as UVR decreases with increasing latitude (Madronich et al., 1995). However, both ground-based measurements and satellite-estimated data have provided evidence that UVR levels have increased over large geographical regions as a result of ozone depletion (WMO, 2010). Ozonesonde observations at the South Pole since the mid-1900s consistently indicate that more than 90% of the ozone in Antarctica is removed each winter (Hofmann et al., 2009; Krzyścin and Sobolewski, 2018).

Regulation of the photosynthetic apparatus provides protection to algal cells against damaging irradiance, as well as maximizing their light-harvesting ability for optimum photosynthesis (Goncalves et al., 2001). Microalgae exhibit various strategies to avoid over-excitation of the photosynthetic apparatus by modulating the balance between energy (light) input and sink activity brought about by changes in the composition and structure of light-harvesting complexes, photosystem stoichiometry (Huner et al., 1998) or carbon fixation activity (Morgan-Kiss et al., 2006). Phototrophs face a dilemma in that they require sunlight to drive photosynthesis but are vulnerable to high UVR levels which may lead to failure in photoprotection and are then harmful to the photosynthetic organisms (Heraud and Beardall, 2000; Wong et al., 2007, 2011). Effects of UV radiation on photosynthetic performances of diatoms, cyanobacteria, green algae and higher plants (Li and Gao, 2014; Zeeshan and Prasad, 2009; Bischof et al., 2002; Fernández et al., 2016) have been reported. Changes in photosynthetic efficiency and heat dissipation from cells can be detected by measuring the yield of chlorophyll fluorescence, which can also be used as an early stress indicator (Pedrós et al., 2008).

Meador et al. (2009) reported a strong correlation between UVB and DNA damage in marine microorganisms. Strong UVB radiation can cause DNA to form thymine dimers which affect normal cell metabolism and division (Yarosh, 2002). The DNA damage can be determined

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