The increase of UV-B radiation (280 nm - 320 nm) in the solar spectrum due to the depletion of the stratospheric ozone causes enhanced exposure to UV-B, which is
dangerous for all living cells, but especially to photosynthetic organisms due to their light dependency. In search of the basis of UV tolerance in terrestrial cyanobacteria, liquid cultures Nostoc commune derived from field material were treated with artificial UV-B and UV-A irradiation. The induction of various pigments which are thought to provide protection against damaging UV-B irradiation were studied. First, UV-B irradiation induced a rapid increase in carotenoids, especially echinenone and myxoxanthophyll, but did not influence chlorophyll a. Second, an enormous increase of an extracellular, water-soluble UV-A/B-absorbing mycosporine occurred, which was associated with extracellular glycan synthesis. Finally, synthesis of scytonemin, a lipid-soluble, extracellular pigment known to function as UV-A sunscreen was observed. After longtime exposure the UV-B effect on carotenoid and scytonemin synthesis ceased while the mycosporine content remained constantly high. It is proposed that the outer membrane-bound carotenoids provide a fast, active SOS response to counteract acute cell damage whereas the glycan with its UV absorbing pigments is a passive UV screen against longtime exposure. The UV-B sunscreen mycosporine is exclusively induced by UV-B (< 315 nm). The UV-A sunscreen scytonemin is only slightly induced by UV-B (< 315 nm), very strongly by near UV-A (350 - 400 nm) and not at all by far UV-A (320 - 350 nm). These results may indicate that the synthesis of these UV sunscreens is triggered by different UV photoreceptors. By applying two-dimensional (2D) gel electrophoresis coupled to computerized image analysis and database analysis the influence of UV was monitored on protein level. UV-A had only little influence on the protein pattern, nevertheless, it had remarkable influence on the pigment composition. In contrast, UV-B led to tremendous changes in the protein expression profile of N. commune. At least 493 proteins of 1350 protein spots analyzed displayed statistical significant changes in their relative rate of synthesis. A programmed acclimation to the new growing conditions was observed. In contrast to shock proteins, which are usually bulk proteins, the majority of stimulated proteins during UV-B acclimation were low abundant 'acclimation' proteins. Cytosolic water-soluble proteins showed different kinetics in their response compared to membrane-associated and membrane-bound proteins. The cellular adjustment resulted in alternative metabolic fluxes under this stress conditions. Like the physiological reaction, the reaction on the protein level could be divided in two phases. Early acclimation response within the first 24 hours, and late acclimation response which requires one up to three days. Most of the protein changes observed during early acclimation were transient. The importance of long time studies for a holistic understanding of UV tolerance in cyanobacteria is discussed. The presented study is the first global study of UV-B effects on the proteome of cyanobacteria and demonstrates the complex physiology of UV-B adaptation.
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