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Protective mechanisms and responses of micro-fungi towards ultraviolet-induced cellular damage

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ABSTRACT

Fungi are microbes that play vital roles in nutrient cycling in the natural environment and in symbiotic interactions with plants and other microbes. They thrive successfully even when challenged by various abiotic and biotic stress factors in the natural environment. Their growth, conidia production, survival, germination, pathogenicity, virulence and bioactive compound production can be strongly influenced by exposure to solar ultraviolet radiation. Different adaptive mechanisms are used to protect the cells and to maintain DNA integrity, enabling survival of exposure to solar ultraviolet irradiation in natural environments. Counter to these abilities, failure to protect cells against damage induced by ultraviolet radiation can compromise genetic integrity and survival, and alter species composition within the fungal community. We reviewed a large body of work on the biological and environmental factors that influence the protective mechanisms employed by micro-fungi in response to exposure to solar ultraviolet radiation, thereby increasing understanding of adaptive responses in micro-fungi.

1. Introduction

Solar radiation provides the energy that drives almost all biological activities on Earth, as well as underpinning the environmental cues that regulate morphological and developmental processes in many organisms. The ultraviolet spectrum can be divided into three distinct wavelength bands of progressively increasing energy: UV-A (320–400 nm), UV-B (280–320 nm) and UV-C (100–280 nm) (Braga et al., 2015; Coblentz, 1932). The Earth's stratospheric ozone layer absorbs these bands differentially, completely excluding wavelengths below 290 nm, thus only UV-A and B are capable of reaching the planet's surface (Caldwell and Flint, 1997; Williamson et al., 2014). The change of solar UVR is most pronounced towards the poles, particularly in the Southern Hemisphere, influenced by cloud transmittance, global atmospheric circulation and anthropogenic greenhouse gases (Bais et al., 2011, 2015; Stevenson, 2009). Exposure to high levels of solar ultraviolet radiation (UVR) can be damaging, inducing many morphological, physiological and biochemical changes that, as well as impacting the cell or organism itself, can lead to changes in community composition, and ecosystem functioning and services (Mishra et al., 2017; Paul and Gwynn-Jones, 2003). While today much attention in both public and scientific research communities is focused on ‘global warming’, particularly in the contexts of increasing atmospheric and oceanic temperatures, changing weather and precipitation patterns, and ocean acidification, it is important to recognize that solar radiation forms a key element of the physical environment for many organisms. Its biological impact in the polar regions has been a focus of attention particularly in the southern regions, associated with the annual development of the Antarctic ‘ozone hole’, and studies examining its impacts on organisms ranging from aquatic microbes to terrestrial plants (Day et al., 2001; Smith et al., 1992; Xiong and Day, 2001). It is often assumed that soil microbial communities are likely to be minimally affected by UVR, due to the physical characteristic of UV-B wavelengths not penetrating deeper than 100 μm into the soil horizon (Johnson, 2003). However, a growing body of microbiological research on the effects of UVR gives clear evidence that its impacts are more complex and pervasive than widely expected.

Mechanisms involved in protection against environmental stress are

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