The effects of space radiation on filamentous fungi

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Abstract:
Aspergillus was the main fungal genera detected aboard the Russian Space Station (Mir) and the International Space Station (ISS), and fungal growth has been shown to promote biodegradation of the spacecraft materials and compromise life-support systems [1-2]. Moreover, as spore formers, filamentous fungi are a threat to astronauts' health, and their resistant spores may pose a threat to planetary protection. This makes monitoring and controlling fungal contamination a challenge to be met in the current and future space missions [3-5]. The topic of my master internship at the DLR is: Fungal spore resistance to space radiation and mechanisms by which observed resistance is mediated.
Studies on the survivability and morphology of A. niger towards space radiation were performed by exposing wt (N402), a melanin mutant (MA93.1) and two DNA repair mutant strains (MA78.6 and MA234.1) to varying dosages and types of simulated space radiation. These strains were chosen to elude which mechanisms (repair or protection) are important for fungal spores against space radiation. Spores (107 for each condition) in a saline solution were for X-rays irradiated at DLR (Cologne, Germany) and for heavy ions at the HIMAC (heavy ion medical accelerator) in Chiba, Japan. For X-rays the dosage ranged from 0-1000 Gy, for Helium (He) nuclei radiation from 0-250 Gy and for Iron (Fe) nuclei radiation from 0-500 Gy. After the irradiation the samples were limited diluted and plated to determine the number of colony forming units and therefore survivability.
Results indicate high spore resistance to X-rays, with the LD90 dose for the wild-type strain N402 being 250 Gy. DNA repair mutant spores show decreased survival upon X-ray radiation, with the LD90 of these strains upon X-ray irradiation being around 50 Gy. The melanin mutant strain does not show decreased susceptibility to X-rays. When the spores are irradiated in different environments (dried versus submerged and with or without salt), it's shown that the lack of H2O decreases the survivability of the spores after the irradiation. He and Fe nuclei radiation also showed a killing effect on the spores. But while He irradiation shows the same killing efficiency as X-rays do, Fe radiation shows an increased killing capacity of the fungal spores compared to X-ray and He radiation. Interestingly, exposure to X-ray, Fe and He radiation showed that the spore's ability to germinate was still intact after exposure to an astonishing 1000 Gy, respectively 500 Gy and 250 Gy. Further work with fungal isolates from the ISS is being done to identify differences in radiation resistance and growth rate under simulated microgravity.
From the results we can conclude that the DNA repair pathway plays, as expected, an important role in the survivability of fungal spores against high energy space radiation, while melanin doesn't have a protective effect. Thereby, the absence of water in the environment of the spores promotes the killing by high energetic radiation. This work paves the way to research eluding the effects of mutating radiation on the fungus in terms of antifungal resistance, their pathogenicity and their capacity to biodegrade space materials.

References
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