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Radiation Fields, Effects and Risks in Human Space Missions (4)

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RESPONSE OF PHASEOLUS VULGARIS L. PLANTS TO LOW-LET IONIZING RADIATION: LEAF ANATOMY AND CYTOLOGY

Abstract

Understanding the effect of Space factors on plant growth is necessary to achieve plant cultivation in Space which is a requisite for the realization of long-duration exploratory-class manned missions. Plant-based Bioregenerative Life Support Systems (BLSSs) fulfil the requirements of: a) regenerating the ambient air in the pressurized modules (photosynthesis), b) aiding water recovery (transpiration), c) contributing to the recycling of astronauts' wastes. When chosen species are crops, plants cultivated in BLSSs can furnish fresh food to meet crew nutritional needs. Furthermore, plants contribute to psychological support against the stress of the mission and conditions of isolation. Ionizing radiation is one of the main factors influencing plant growth in Space at molecular, morpho-anatomical, biochemical and physiological levels. Although experimentation in Space would be preferred, on-ground preliminary tests are needed before on-board experimentation. The aim of this study was to investigate the effect of X-rays on leaf anatomy and cytology in Phaseolus vulgaris L. Plants in active development during the vegetative phase were irradiated with different doses of X-rays to evaluate the effect of radiation on: a) leaves at complete life span, and b) leaves while developing. Such an experimental design allowed to distinguish between the modification of those plastic traits inducible promptly after irradiation and the structural alterations occurring during organogenesis. In the first case, particular attention was addressed to the analysis of phenolic compounds which are generally increased in plants subjected to stress conditions and can contribute to tissue photo-protection. Regarding structural properties, the characterization of all tissues was carried out with specific emphasis on those traits affecting photosynthetic efficiency. Leaves of irradiated and control plants were sampled, fixed, embedded in resin and cross-sectioned through a microtome. Thin sections were analysed through light and epi-fluorescence microscopy. Digital photomicrographs were analysed through digital image analyses systems to quantify cytological and anatomical parameters such as: cell size and shape in the various tissues; incidence of lignified and suberized areas; number, size and morphology of lignified elements in vascular bundles; thickness of cell walls; appearance, localization and incidence of phenolic compounds. Results showed that anatomical and cytological traits are differentially affected by different radiation levels. The overall structural data were complemented by chemical quantification of phenolic compounds. All data were discussed considering the relations between structure and functions especially in terms of the possible role of structural modification in the maintenance of high capability of radioresistance and induction of antioxidative-defense mechanisms.