TITLE – PLANTS IN EXTREME ENVIRONMENTS: FOCUS ON SPACE

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INTRODUCTION: Plants are vital organisms on Earth since they provide oxygen and food, maintaining life on our planet. For their essential ecosystem role, plants could also be important in environments other than Earth. The idea to use plants to support life in Space is increasing in interest in the last decades because they could serve as crucial elements in Controlled Ecological Life Support Systems (CELSS) conceived to sustain human wellbeing in long-duration space missions. The role of plants in CELSS would be crucial for food production and resource regeneration (i.e., carbon dioxide removal, oxygen production, water purification) directly on board. However, plants' engagement on the Space platform requires deep knowledge of the functioning of the vegetal systems under the effect of Space factors, mainly altered gravity and ionizing radiation. There is a mutual opinion that plants may survive in Space, but it is uncertain their performance in such an environment. The extreme high plasticity and adaptation capacity of plants to the changing environment allowed their colonization in many habitats on Earth. From an evolutionary perspective, space radiation and altered gravity might be considered the primary factors driving the evolution of plants in Space. Therefore, in the view of the potential colonization of extraterrestrial environment by higher plants, it is reasonable to hypothesize a sort of "back to the origin" because plants would face ecological conditions similar to those of remote past on Earth: microgravity and increased doses of ionizing radiation.

OBJECTIVES:

The main objective of this study was to evaluate plant's response to different doses and types of ionizing radiation in crop-model species, such as tomato, soybean, bean and chard, through a multidisciplinary approach, analyzing different molecular, eco-physiological and biochemical aspects in order to identify the mechanisms associated with plant radioresistance.

METHOD / DESIGN:

The study has been conducted on different crops by integrating non-destructive gas exchange and chlorophyll fluorescence emission measurements, for the quantitative estimations of photosynthesis, with enzymatic and molecular essays to assess photosystems' functionality and overall plant health status.

RESULTS:

A selection of results demonstrated that ionizing radiation might exert opposite effects on plant growth and photosynthesis, ranging from detrimental outcomes at high doses, harmful consequences at intermediate levels, and stimulatory effects at low doses. The severity of the effects depends on several factors, including radiation-related parameters (e.g., dose, Linear Energy Transfer - LET) and organism-related traits (e.g., species, plant physiological status, plant developmental stage at the time of irradiation). Our studies demonstrate that the seed is the most resistant stage to IR, which does not prevent the achievement of the seed-to-seed cycle. From a physiological point of view, plants irradiated at the vegetative stage are the most sensitive showing a reduction of photosynthetic efficiency and the occurrence of DNA polymorphisms. A relevant aspect is that low doses of ionizing radiation exert a stimulatory effect on photosynthesis and the production of bioactive compounds in leaves and fruits, revealing a tool to improve the nutraceutical properties of tissues.

CONCLUSIONS:

Our experiments support the studies that demonstrated that plants tolerate ionizing radiation, maintaining vital functions also at high doses. Plant radioresistance is a fundamental requirement for achieving good photosynthetic performance, which guarantees an adequate resource regeneration on CELSS. In addition, plants enduring ionizing radiation increase the synthesis of secondary metabolites as a defense mechanism, producing fresh food richer in functional compounds. This aspect represents an attractive perspective to supplement the astronaut diet directly onboard.

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