Influence of long term exposure to enhanced gamma radiation levels on biomass production, physiological health and antioxidative status of Arabidopsis thaliana and of Oryza sativa.

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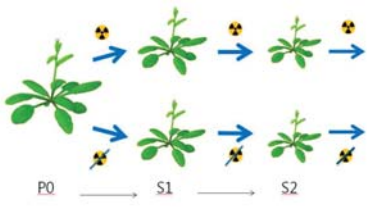
Introduction

Plant growth and physiology in space are of interest and concern for the possibilities for long-term manned space flights. Space conditions might impose stress on plants on several fronts due to confinement, changed atmosphere composition, microgravity and enhanced levels of radiation. Enhanced exposure to ionising radiation can induce genotoxic effects by interacting with DNA either directly or indirectly and as such can induce DNA damage, oxidative stress and lead to alterations in proteins and lipids. In this study the impact on plants of long term exposure to enhanced radiation levels is investigated at different levels of biological complexity (individual to molecular) and compared between lab model organisms like *Arabidopsis thaliana* and the crop plant *Oryza sativa*.

Objectives

- Estimating long term exposure to enhanced radiation within and over generations for both model plants and crop plants
- Different levels of biological complexity from individual such growth, biomass production and seed yield to cellular and molecular endpoints.
- Measuring cellular endpoints include antioxidative enzymes and metabolites indicating nutritional value as well as oxidative stress
- Understanding mechanisms regulating long term responses such as changes in epigenetic marks

A. thaliana multigenerational set up

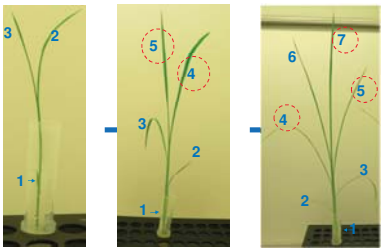


3 generations exposed for 1 out of for 4 different dose rates: from 20 to 420 mGy.h^{-1}

A. thaliana seed to seed exposure

Plants exposed for full six weeks at low dose rates (1mGy.h).

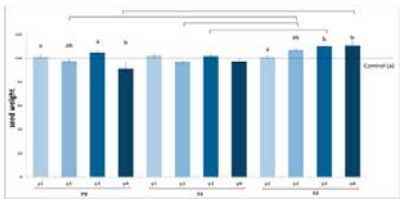
O. sativa exposure and recovery



Different dose rates ranging from 20 to 420 mGy/h. Harvest of Leave 4,5 (exposure), 4,5 and 7 (recovery)

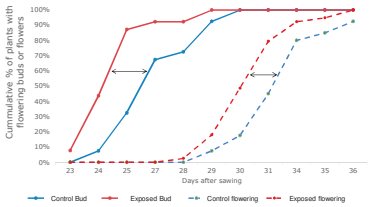
Generation experiments: seed yield

Radiation induces significant changes in seed weight that differ over generations.



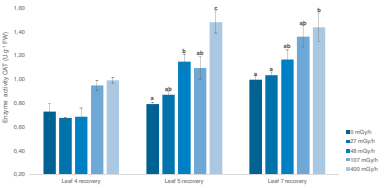
Seed to seed exposure: early flowering

Time of flowering sifted more than two days earlier. This was also observed in generation experiment (data not shown). 1mGy/h exposure



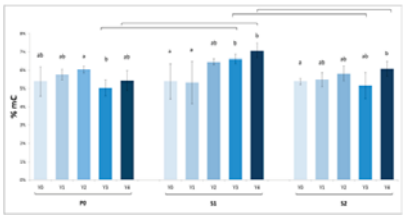
Rice: exposure and recovery: antioxidants

Catalase activity induced during exposure (not shown) and recovery even in unexposed leaves. Similar for other enzymes (data not shown)



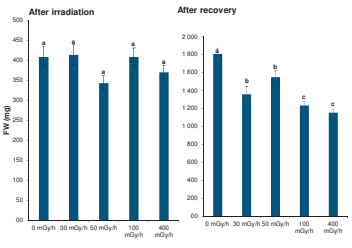
Generation experiments: whole genome methylation levels

Overall methylation highest in S2 generation. Several genes in the methylation pathways showed the same expression pattern, without any significant repressions or inductions.



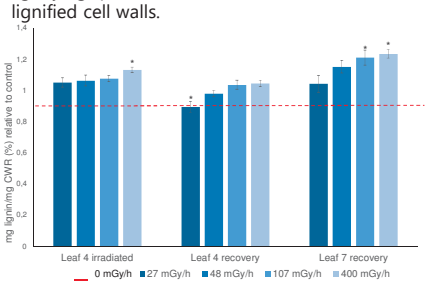
Rice: exposure and recovery: biomass

Overall biomass was reduced especially in recovery.



Rice: exposure and recovery: lignification

Exposure to radiation leads to higher activity of lignifying peroxidases (data not shown) more lignified cell walls.



Conclusion and discussion

- Substantial changes in plant development: early flowering, reduced growth and changed seed weight observed in all conditions and plants tested. Some effects disappear in later generations indicating plant adaptation processes.
- Changed antioxidative enzymes activity like catalase not only in exposed but also recovered plants indicate signalling of the radiation-induced effects
- More lignified cell walls can explain shorter plant phenotype but might also result in less digestible plants. On the other hand increased antioxidants levels (data not shown) and heavier seeds could lead to higher nutritional value.
- *Future experiments will aim at testing radiation-induced changes in nutritional value in plants edible parts grown under space-like conditions.*