Light quality alters the response to ionizing radiation in seedlings of legume species in terms of development and nutritional traits

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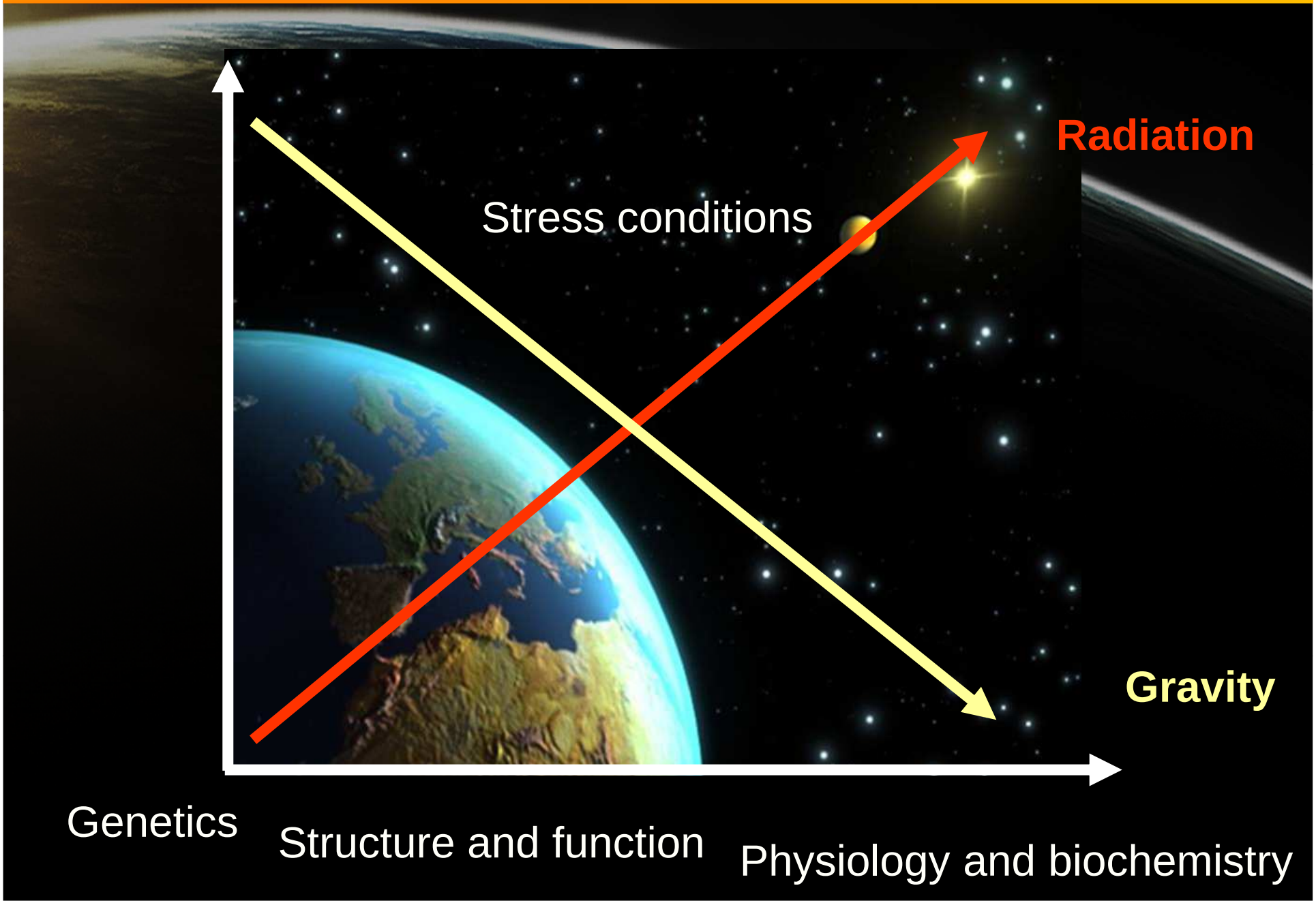
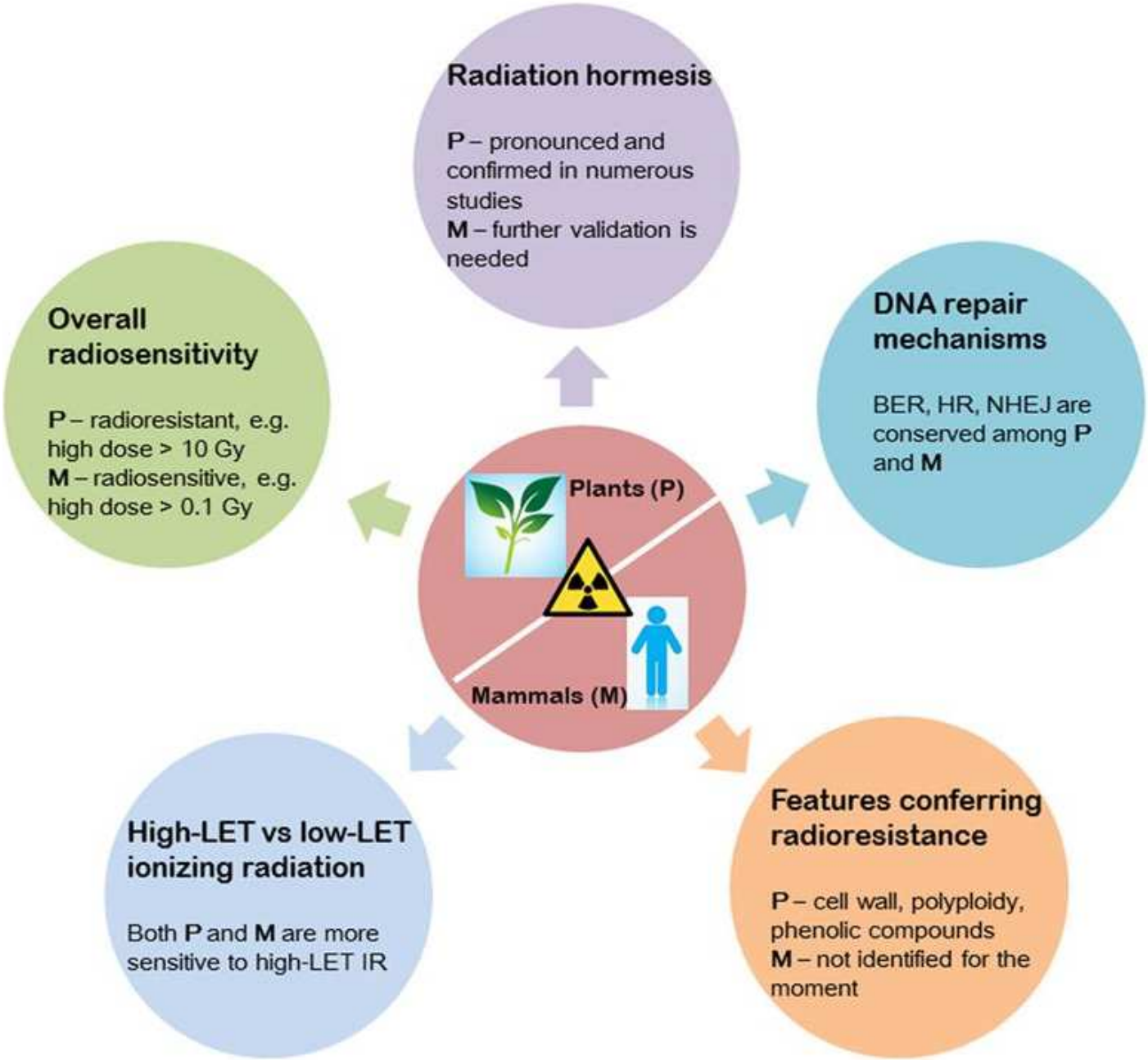
Mission Scenario and Space Constraints



Plants *vs* Mammals



Arena et al. 2014.
Acta astronautica 104: 419–431

De Micco et. Al. 2011.
Radiat Environ Biophys 50: 1-19

Variability of responses

DOSE

high

ROS production, damage to proteins and nucleic acids, reduced growth and early senescence

medium

Decreased development and altered metabolism

low

Occurrence of *hormesis*: increased content of antioxidant compounds, improved nutritional value, stimulation of growth

Type *Dose* *End-point* *Species* *…*

Effects of radiation on plants

Tools

- Space opportunities
- Low-LET radiation
- High-LET radiation

Approaches

- Molecular
- Structural
- Physiological
- Nutritional

Some major alterations

- Molecular alterations: gene expression, chromosome aberration
- Morphological alterations: organelle structure, cell cycle regulation, cell wall, plastids, tissue organization
- Physiological processes: photosynthesis, ROS production, reproduction, production of antioxidant compounds

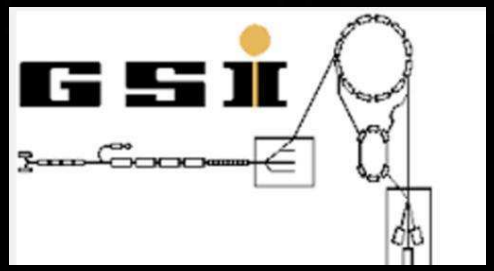
Experiments with radiation

Species

- Dwarf bean
- Azuki bean
- Soybean
- Tomato

Radiation type

- X-rays
- C-ions
- Ti-ions
- Ca-ions



Main issues:

- To explore the dose range where plant sensitivity is expected
- To test if the effects of radiation depend on phenological and developmental phase
- To assess a possible stimulatory effect at low doses

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Effect of heavy ions on development, photosynthesis and fruit antioxidant production in Microtom plants: a Space Perspective

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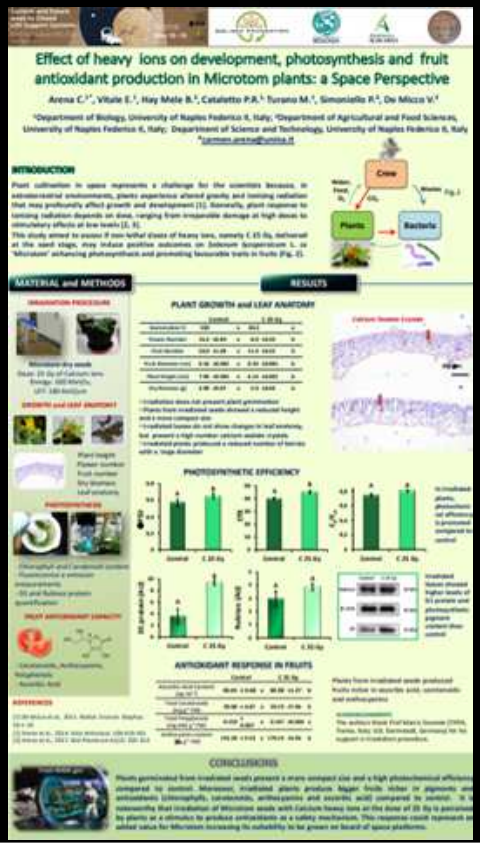
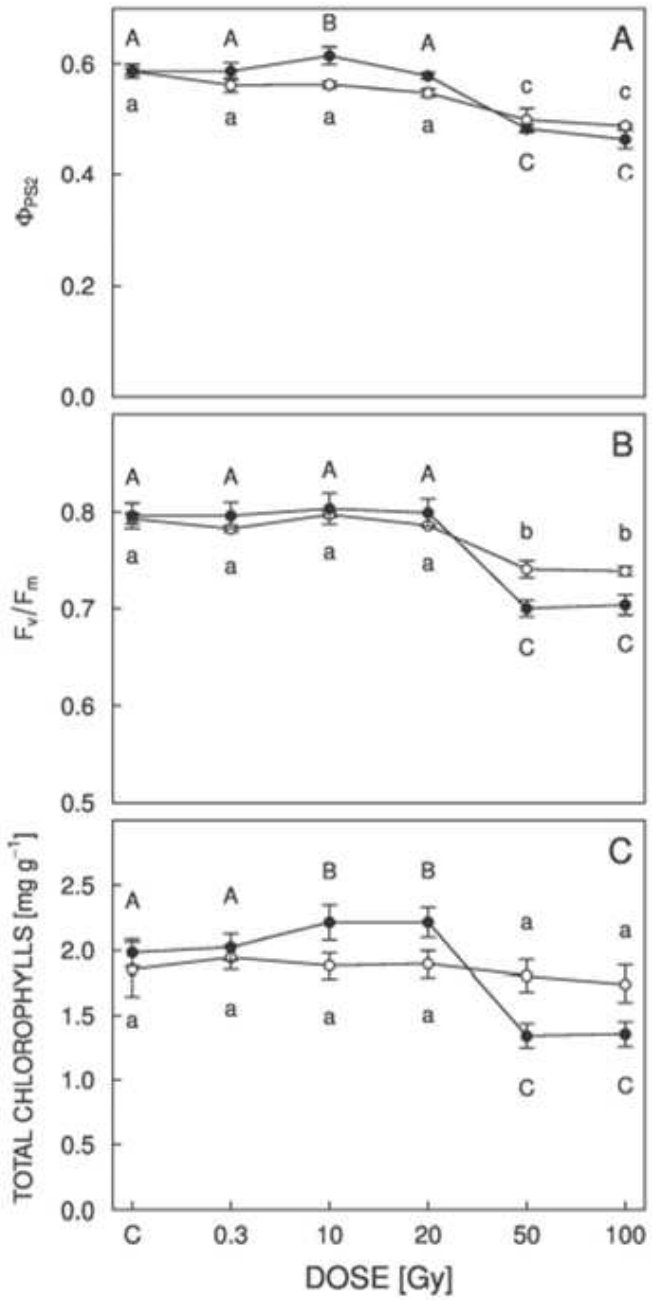
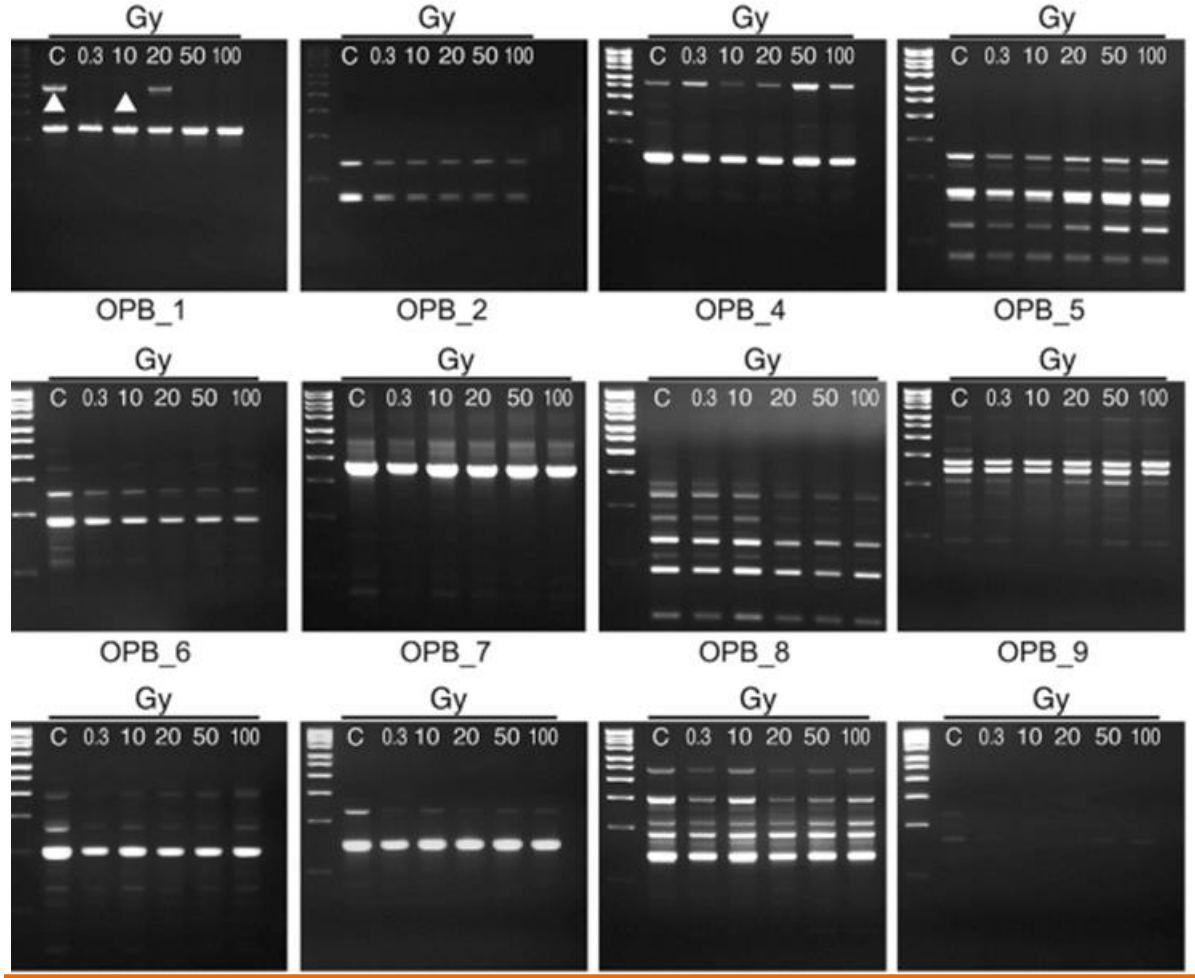
e-poster



Phenotype and DNA polymorphism





DOI: 10.1007/s10535-016-0668-5 BIOLOGIA PLANTARUM 61 (2): 305-314, 2017

Anatomy, photochemical activity, and DNA polymorphism in leaves of dwarf tomato irradiated with X-rays

C. ARENA[1,2]*, M. TURANO[1], B. HAY MELE[3], P.R. CATALETTO[1], M. FURIA[1], M. PUGLIESE[4], and V. DE MICCO[3]

Novel points

Target organ/tissue

- Most experiments have been done by irradiating dry seeds

Interaction with other factors

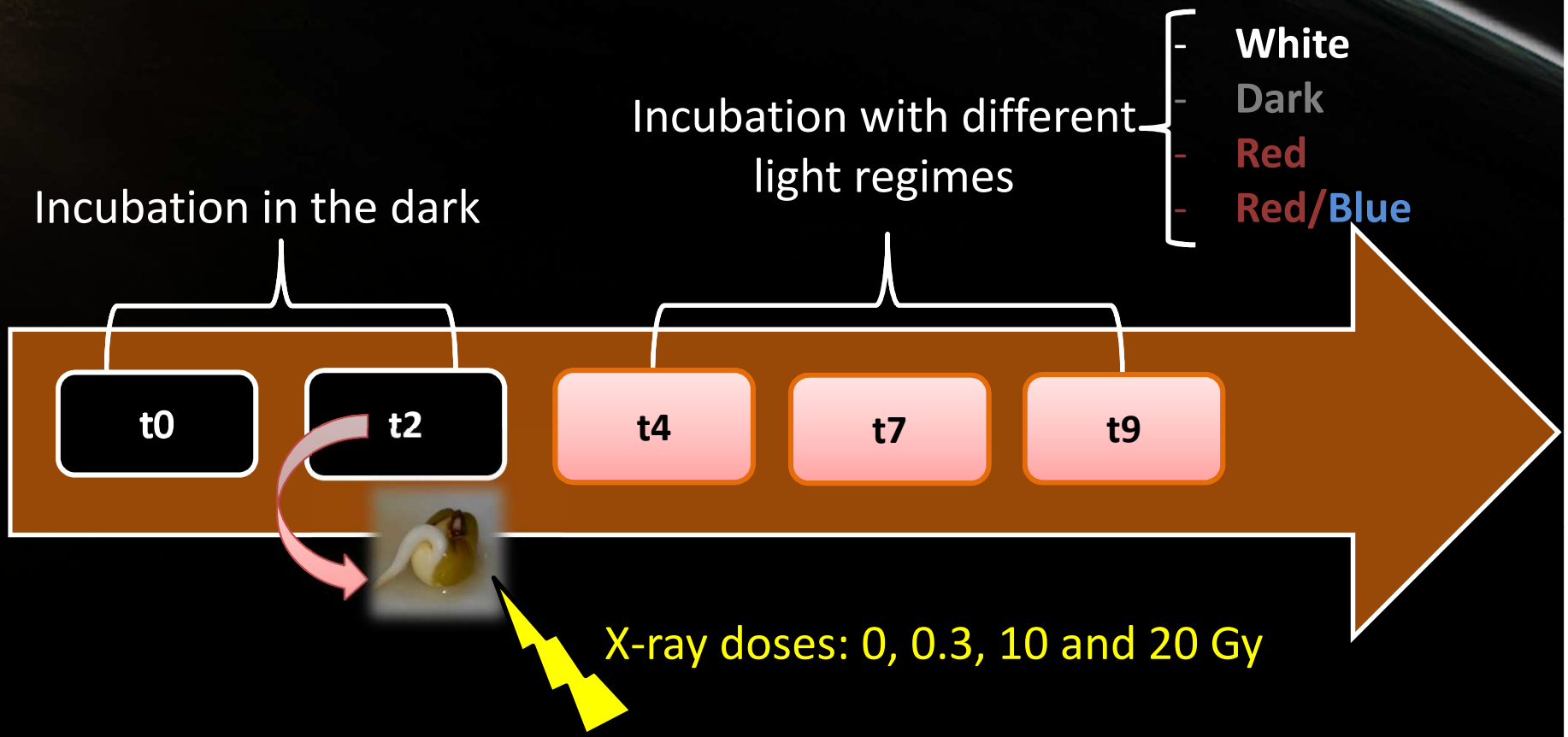
- Scattered information about interaction between factors

The idea:

To manage cultivation factors to modulate responses to radiation

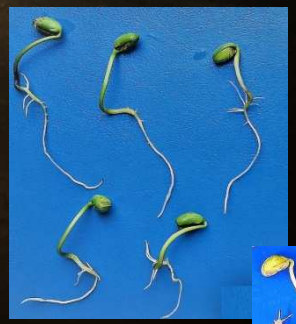
Aim and Experimental Design

To analyze the combined effect of low-LET ionizing radiation and light quality on the development of soybean and Azuki bean seedlings



t4-t9: growth monitoring and sampling for structural and nutritional analyses

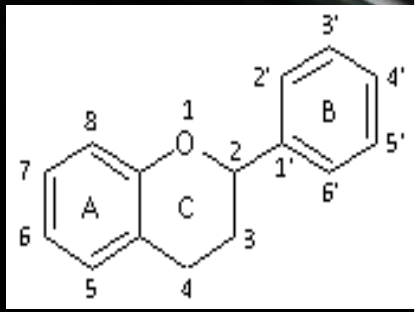
Analyses

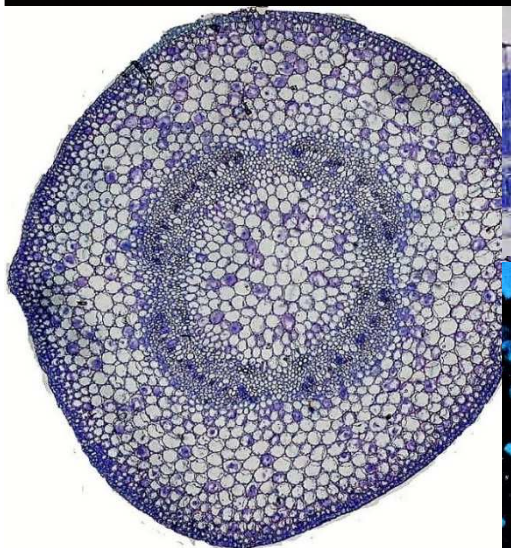


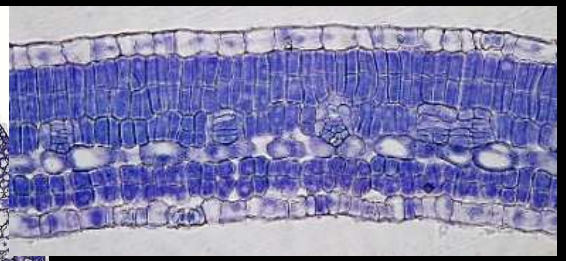
- ***Morphology***
- ***Tissue organization***
- ***Phenolics localization***

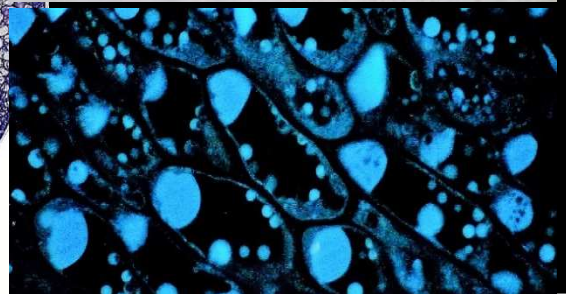
Flavonoids:

- Kaempferol-rutinoside
- Rutin
- Quercitrin
- Naringenin
- Naringin



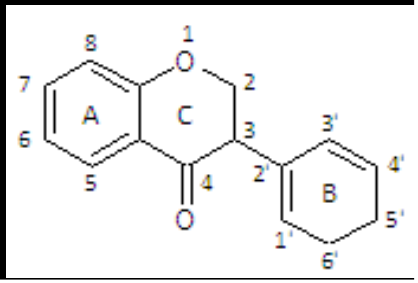


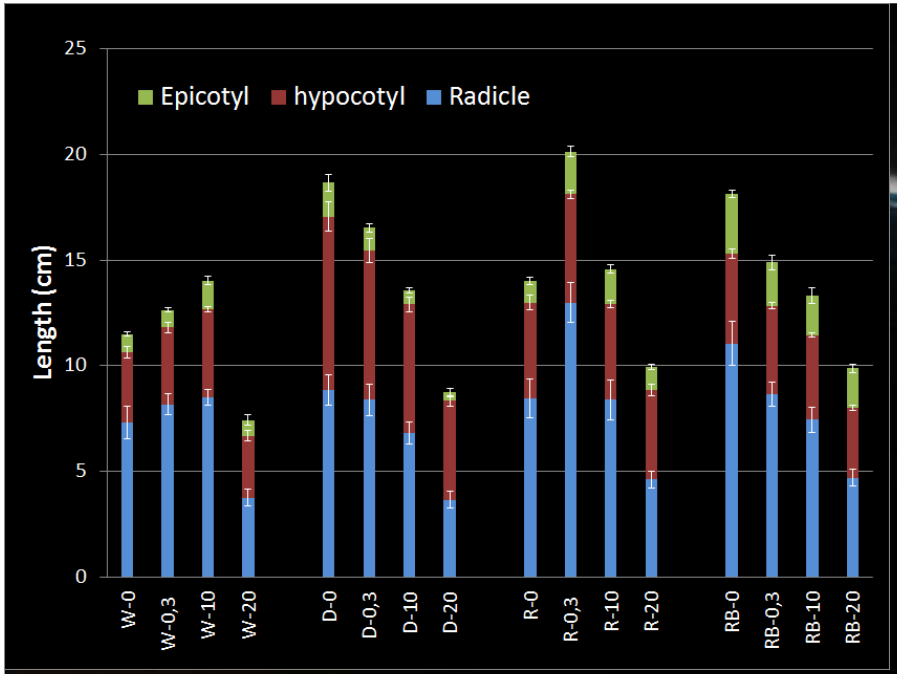


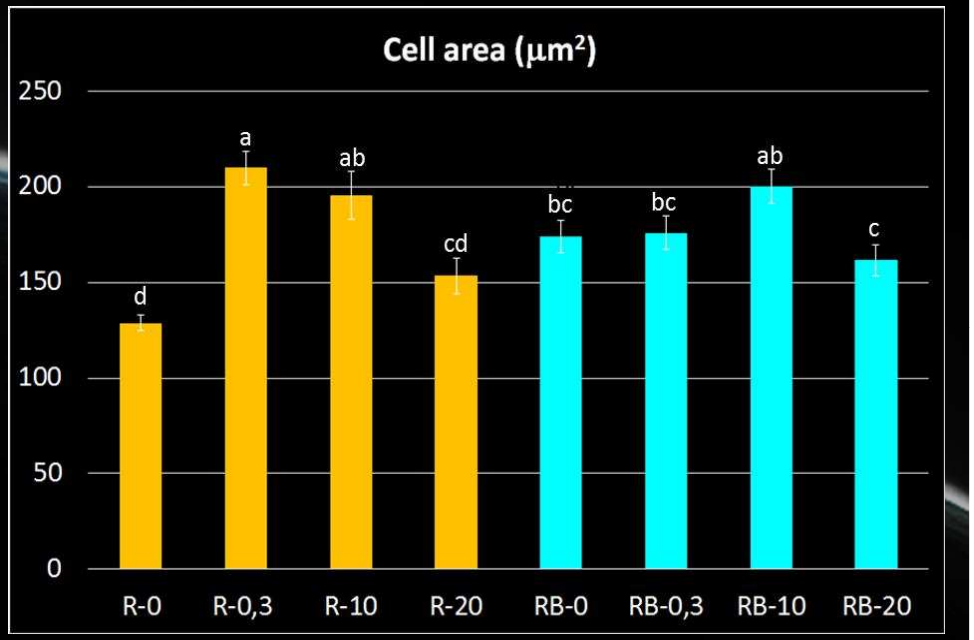


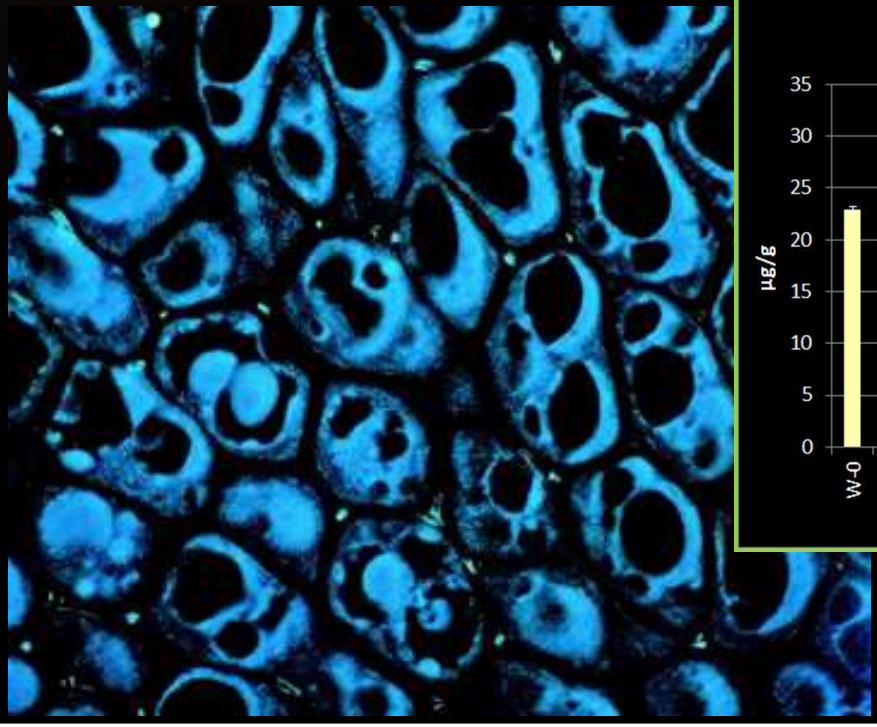
Isoflavonoids:

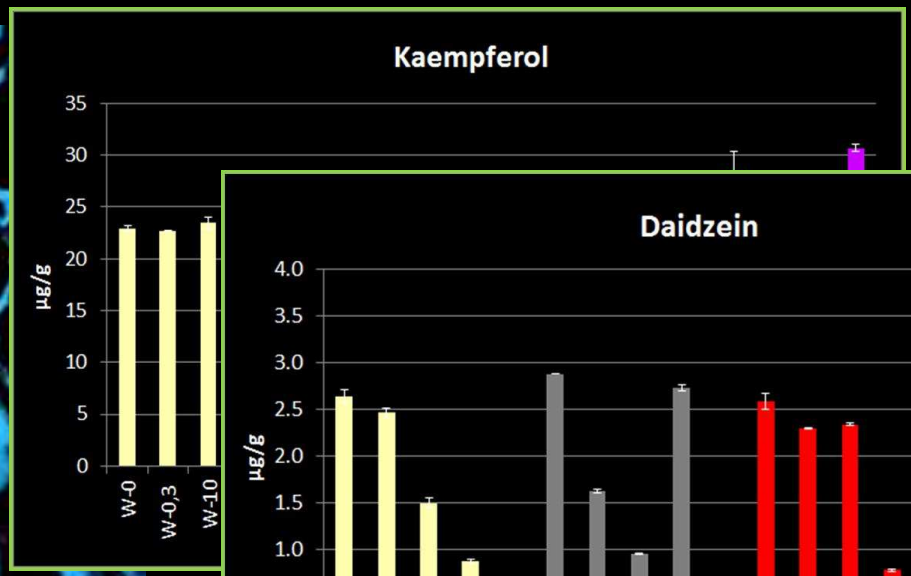
- Daidzin
- Malonyldaidzin
- Glycitin
- Genistin
- Daidzein
- Glycitein
- Genistein




Epicotyl
hypocotyl
Radicle
Length (cm)
0
5
10
15
20
25
W-0
W-0,3
W-10
W-20
D-0
D-0,3
D-10
D-20
R-0
R-0,3
R-10
R-20
RB-0
RB-0,3
RB-10
RB-20


Cell area (µm²)
0
50
100
150
200
250
d
a
ab
cd
bc
bc
ab
c
R-0
R-0,3
R-10
R-20
RB-0
RB-0,3
RB-10
RB-20




Kaempferol
µg/g
0
5
10
15
20
25
30
35
W-0
W-0,3
W-10

Daidzein
µg/g
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
W-0
W-0,3
W-10
W-20
D-0
D-0,3
D-10
D-20
R-0
R-0,3
R-10
R-20
RB-0
RB-0,3
RB-10
RB-20

Conclusion

- The effect of radiation (also *hormesis*) was dependent on light quality
- Very high doses were not responsible for growth abberrations
- Dose-response trends were not always linear
- Radiation-induced increase in antioxidant compounds in bean seedlings can be severely influenced by light quality already at very early stages of development

Take-home message

The interaction between ionizing radiation and other environmental conditions should be taken into account in the shielding design of plant-based modules of bioregenerative systems

Perspective?

- To increase investigations with high-LET radiation
- Looking for opportunities for Space experiments

Collaborations

Marco Durante

Walter Tinganelli

TIFPA Trento Institute for Fundamental Physics and Applications

SEQUENTIABIOTECH SCIENCE DESIGNERS

Walter Sanseverino


Thanks!