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

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**Plants vs Mammals**

**Radiation hormesis**
- P: pronounced and confirmed in numerous studies
- M: further validation is needed

**DNA repair mechanisms**
- BER, HR, NHEJ are conserved among P and M

**Overall radiosensitivity**
- P: radioresistant, e.g., high dose > 10 Gy
- M: radiosensitive, e.g., high dose > 0.1 Gy

**High-LET vs low-LET ionizing radiation**
- Both P and M are more sensitive to high-LET IR

**Features conferring radioresistance**
- P: cell wall, polyploidy, phenolic compounds
- M: not identified for the moment

*References*


Variability of responses

<table>
<thead>
<tr>
<th>Type</th>
<th>Dose</th>
<th>End-point</th>
<th>Species</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>high</td>
<td>ROS production, damage to proteins and nucleic acids, reduced growth and early senescence</td>
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<td></td>
<td>medium</td>
<td>Decreased development and altered metabolism</td>
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<tr>
<td></td>
<td>low</td>
<td>Occurrence of hormesis: increased content of antioxidant compounds, improved nutritional value, stimulation of growth</td>
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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

To test if the effects of radiation depend on phenological and developmental phase

To assess a possible stimulatory effect at low doses

To explore the dose range where plant sensitivity is expected

Main issues:

Species
- Dwarf bean
- Azuki bean
- Soybean
- Tomato

Radiation type
- X-rays
- C-ions
- Ti-ions
- Ca-ions
Effect of heavy ions on development, photosynthesis and fruit antioxidant production in Microtom plants: a Space Perspective

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

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

Incubation in the dark

Incubation with different light regimes:
- White
- Dark
- Red
- Red/Blue

X-ray doses: 0, 0.3, 10 and 20 Gy

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

**Isoflavonoids:**
- Daidzin
- Malonyldaidzin
- Glycitin
- Genistin
- Daidzein
- Glycitein
- Genistein

**Flavonoids:**
- Kaempferol-rutinoside
- Rutin
- Quercitrin
- Naringenin
- Naringin

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

• The effect of radiation (also *hormesis*) was dependent on light quality

• Very high doses were not responsible for growth aberrations

• 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
Thanks!