MELISSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE
2022 MELISSA CONFERENCE
8-9-10 NOVEMBER 2022
CREATING A CIRCULAR FUTURE

Morpho-physiological and nutritional responses of *Brassica* microgreens to heavy ions: an outlook on ionizing radiation from the REBUS project

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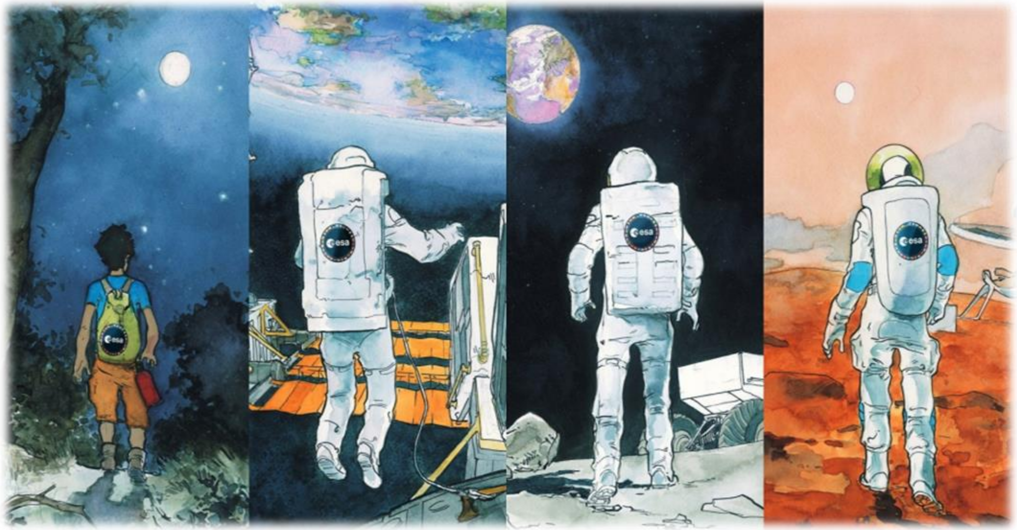
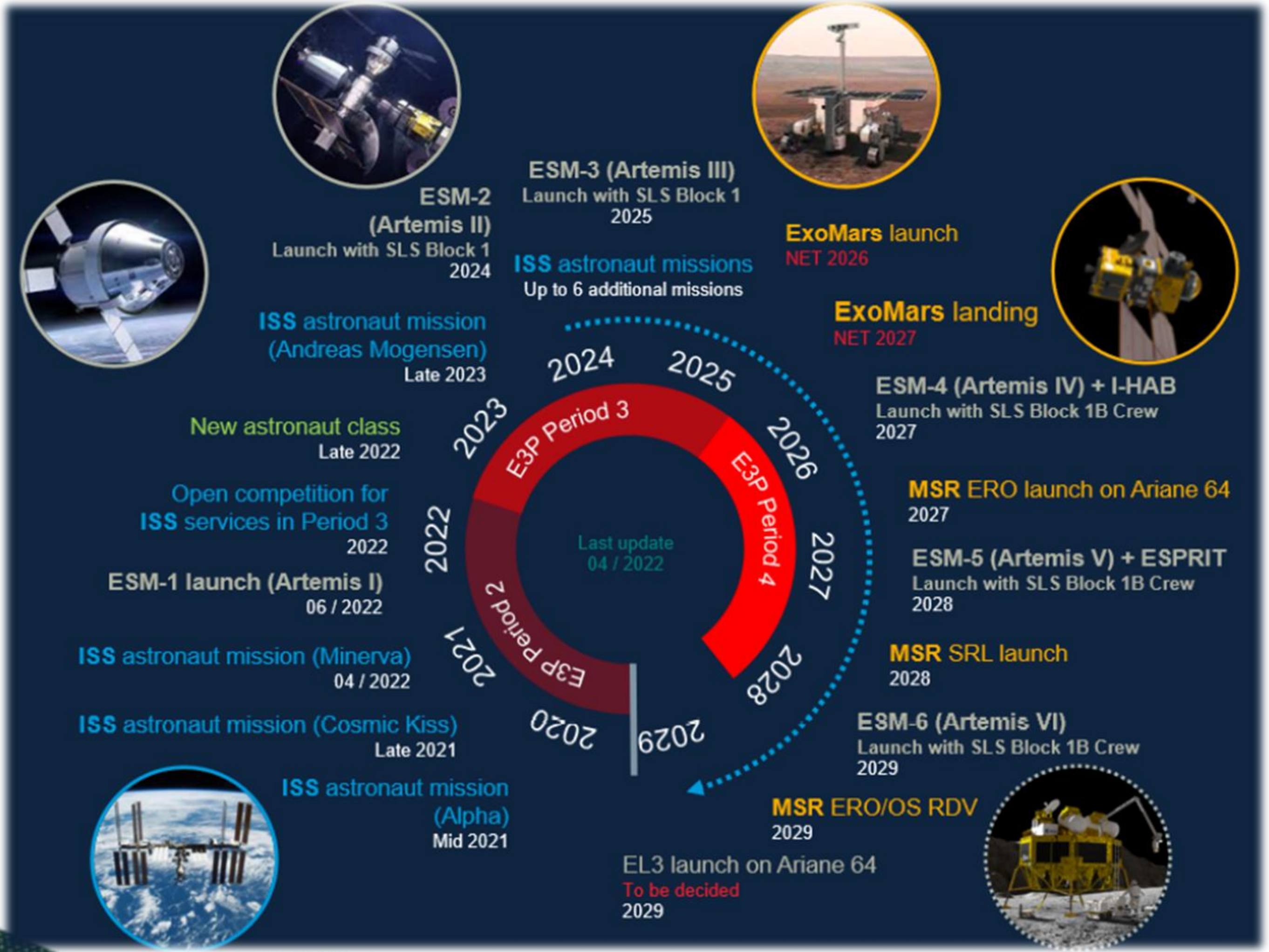
DIPARTIMENTO DI BIOLOGIA
GSI
Plant & Wood Anatomy Lab

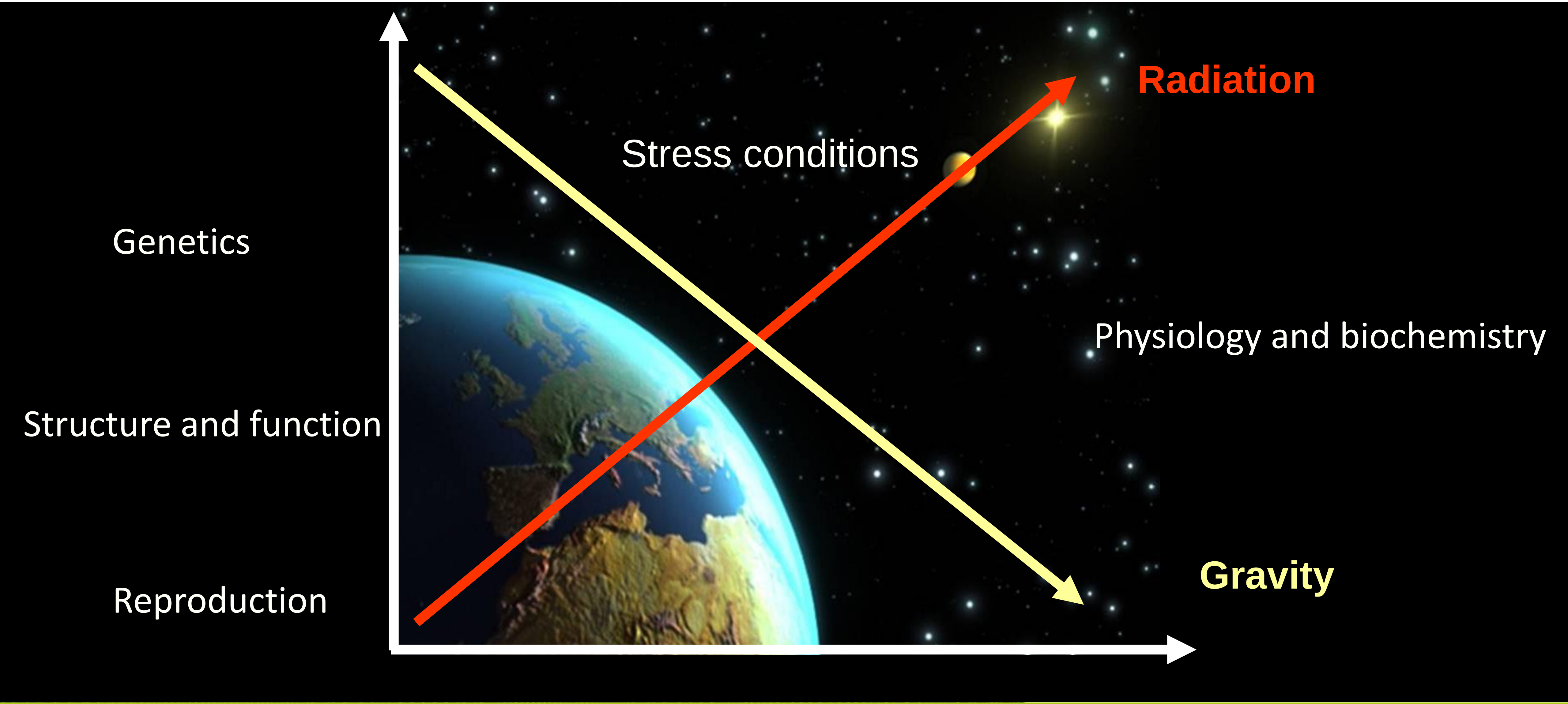
Terrae Novae 2030+ Strategy Roadmap (©ESA)

Exploration goals of ESA

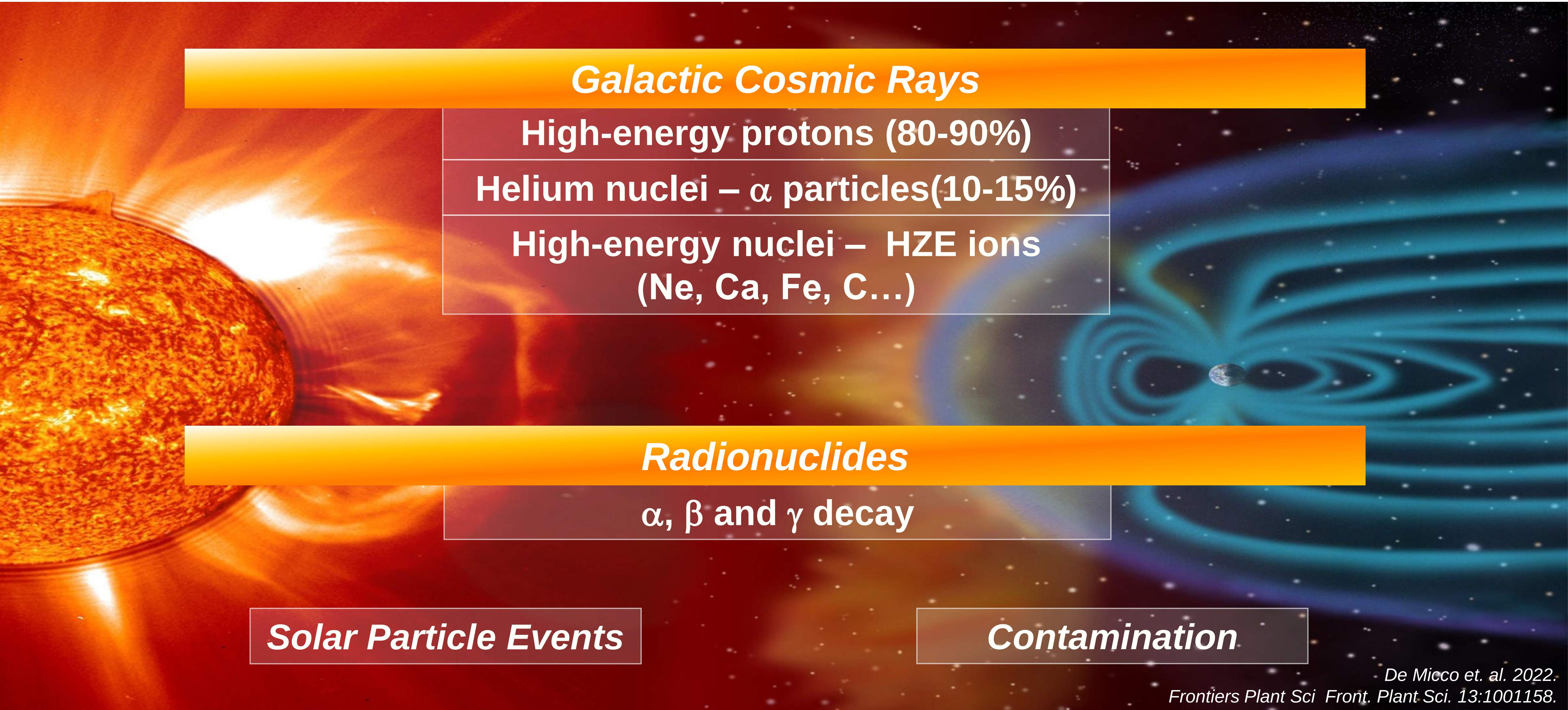




Mission scenario and Space constraints



Ionizing Radiation: variability in space and time



Galactic Cosmic Rays

High-energy protons (80-90%)

Helium nuclei – α particles(10-15%)

High-energy nuclei – HZE ions (Ne, Ca, Fe, C…)

Radionuclides

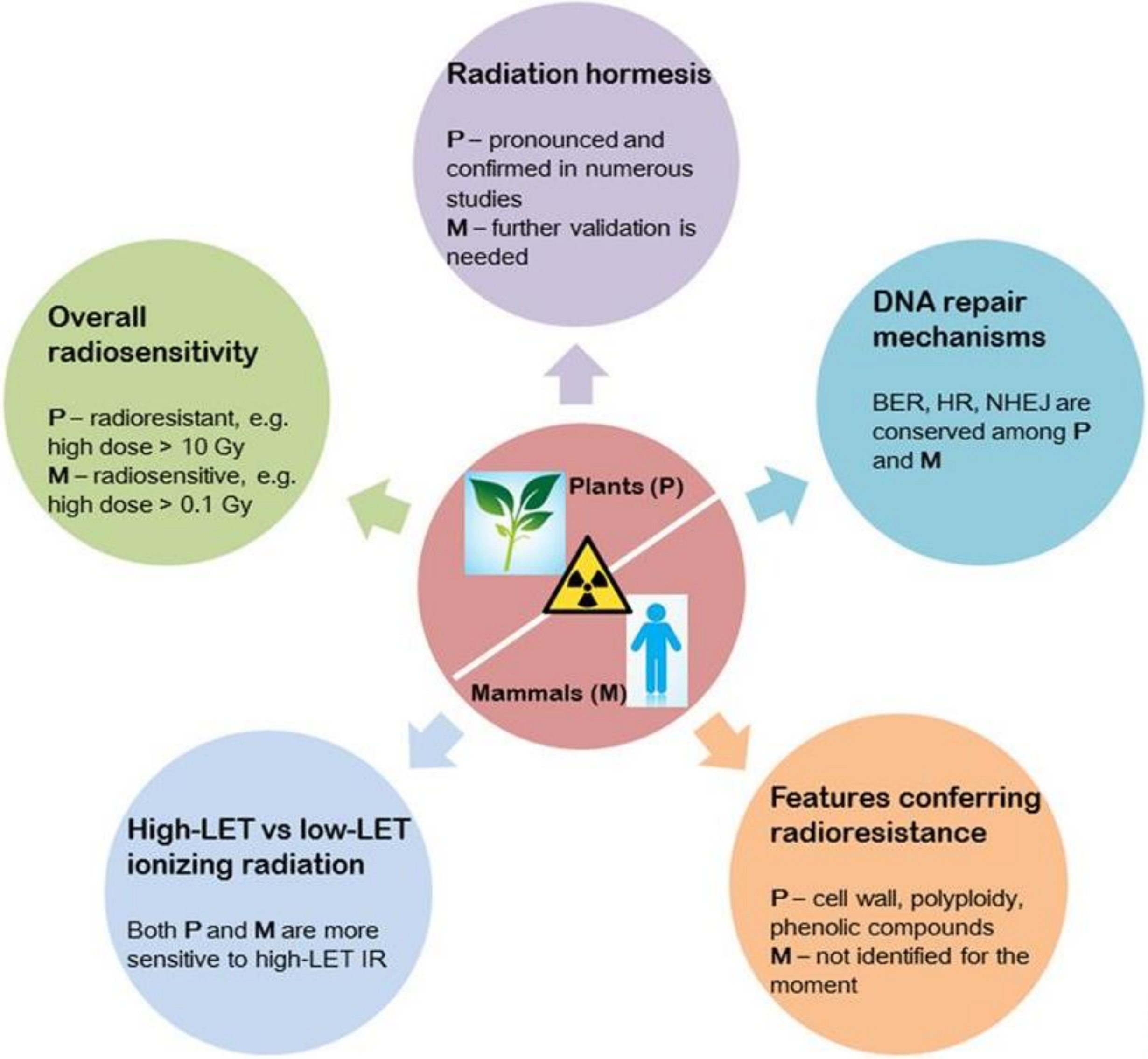
α, β and γ decay

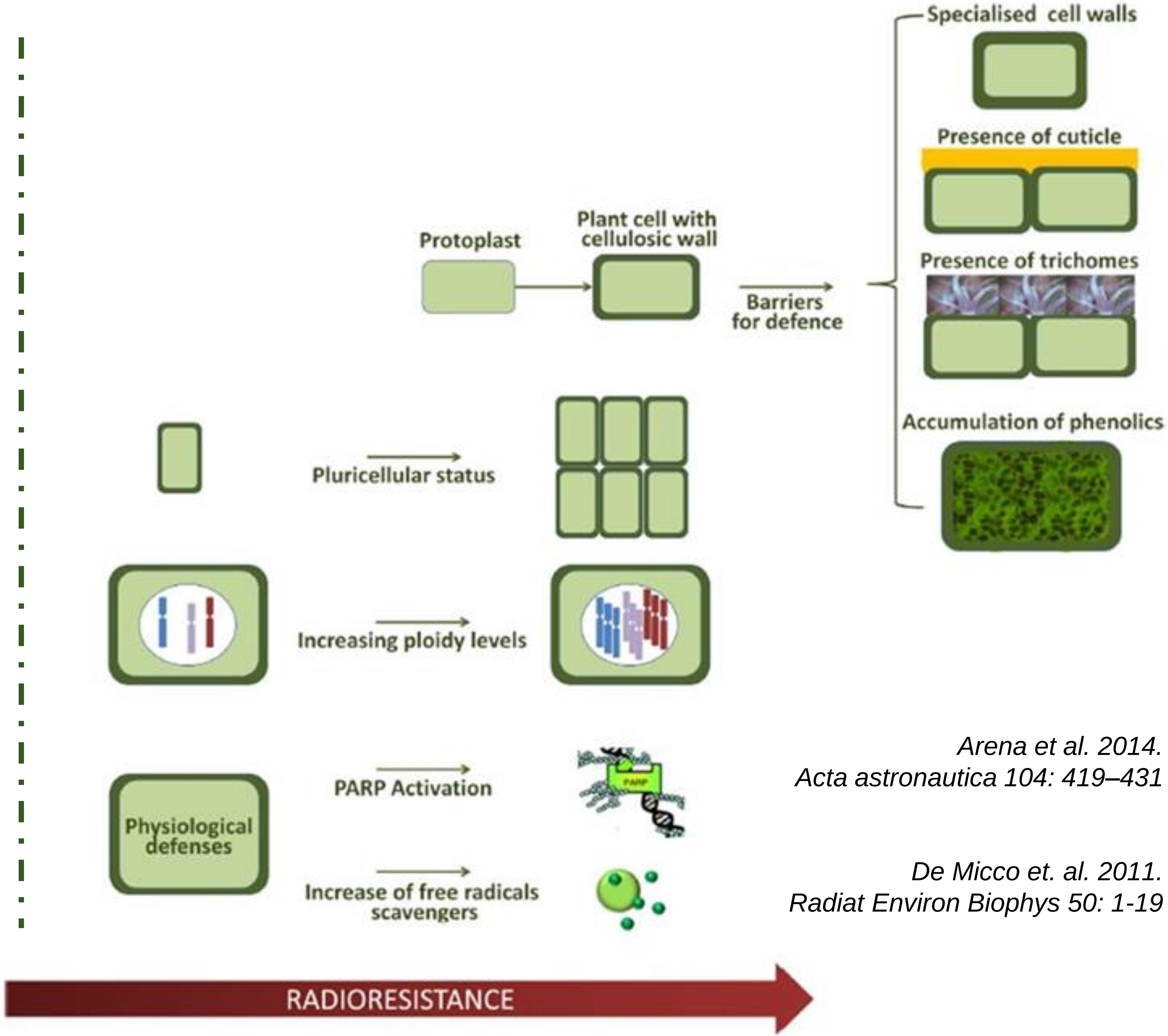
Solar Particle Events

Contamination

De Micco et. al. 2022.
Frontiers Plant Sci Front. Plant Sci. 13:1001158.

Plants *vs* mammals

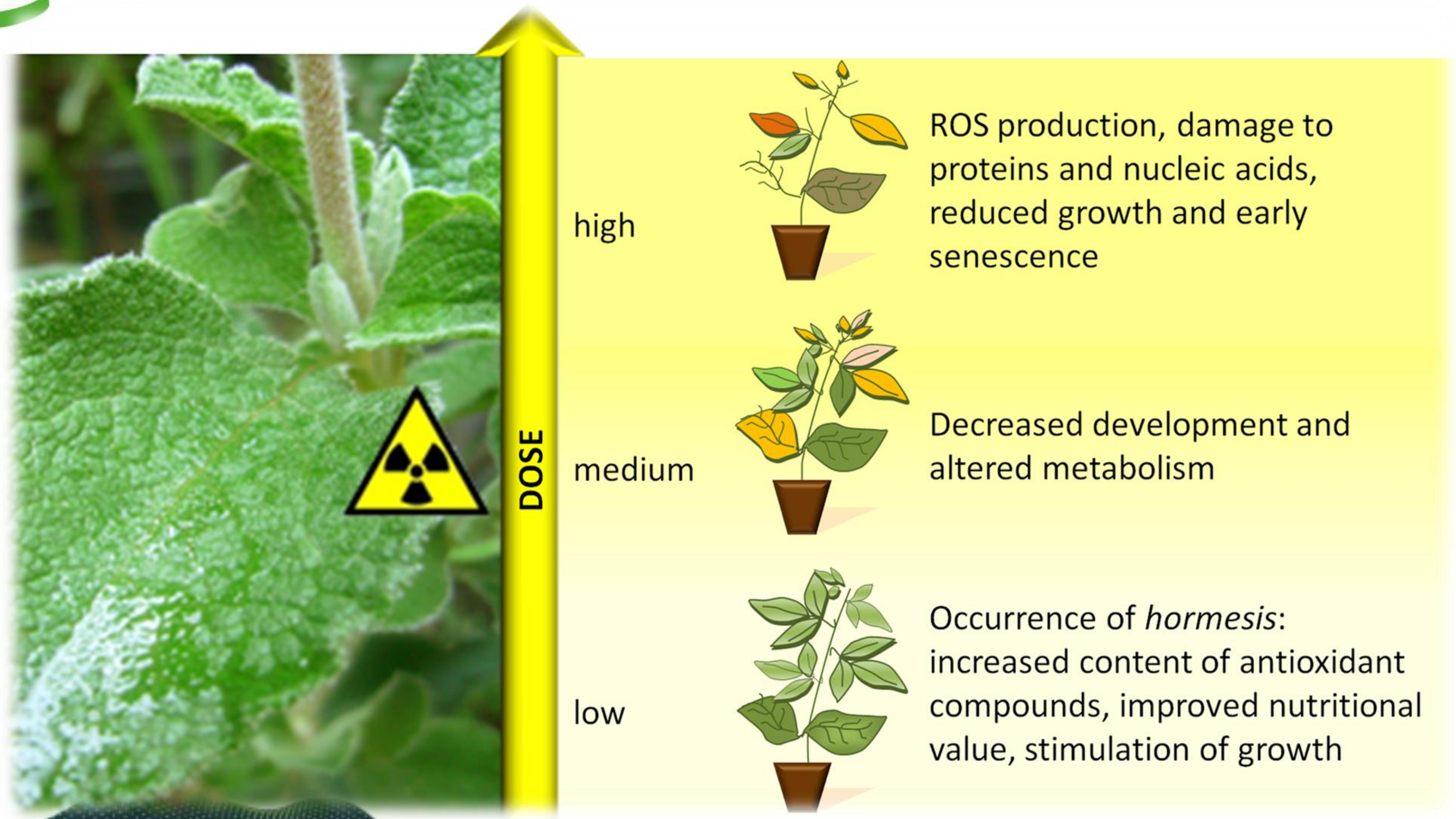




Arena et al. 2014. Acta astronautica 104: 419–431

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

Variability of responses

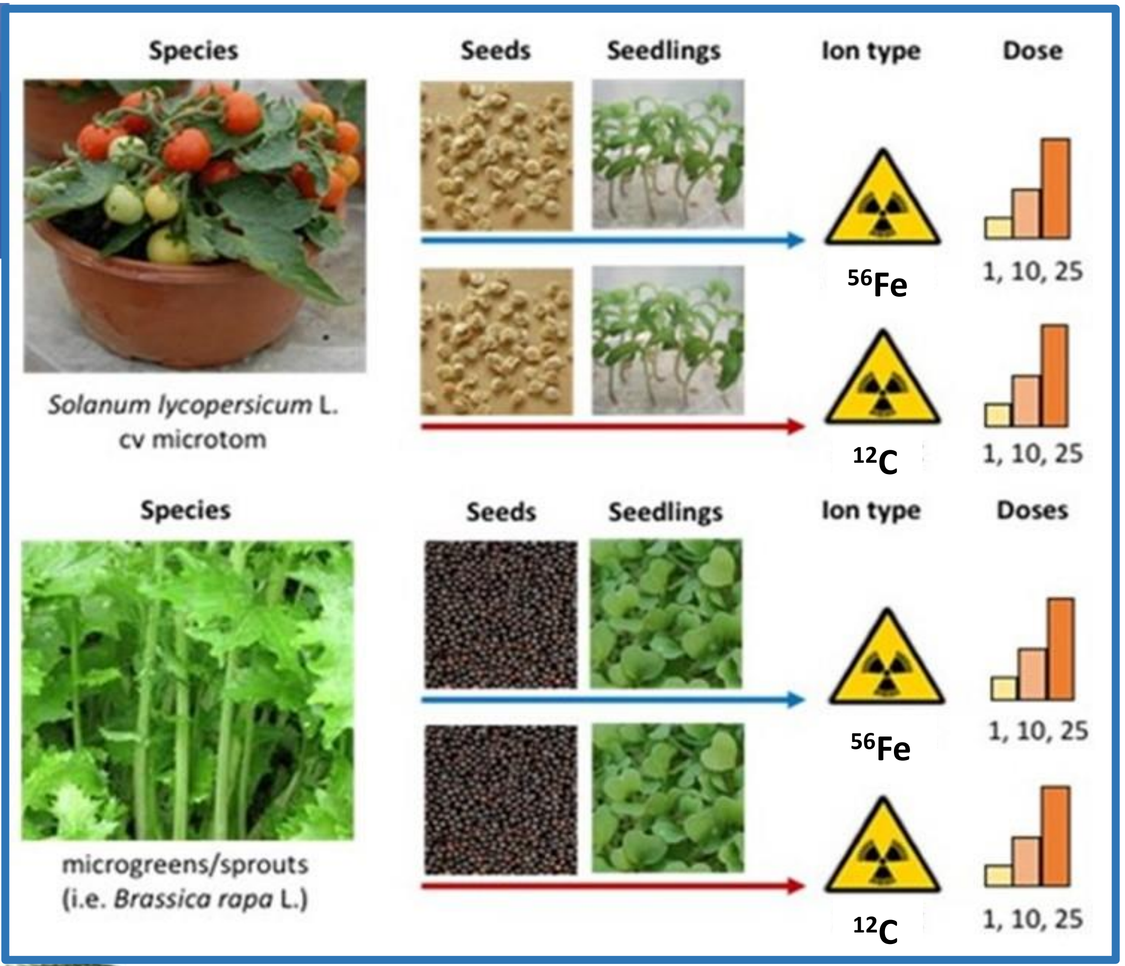


Type
Dose
End-point
Species
…………..

Specific focus of the REBUS project

In-situ Resource Bio-Utilization for life support in Space – Effects of ionizing radiation

- **Radioresistance** mechanisms (*plant functional traits*)
- Impact on the ‘**regeneration**’ value
- Impact on **nutritional value** of edible organs



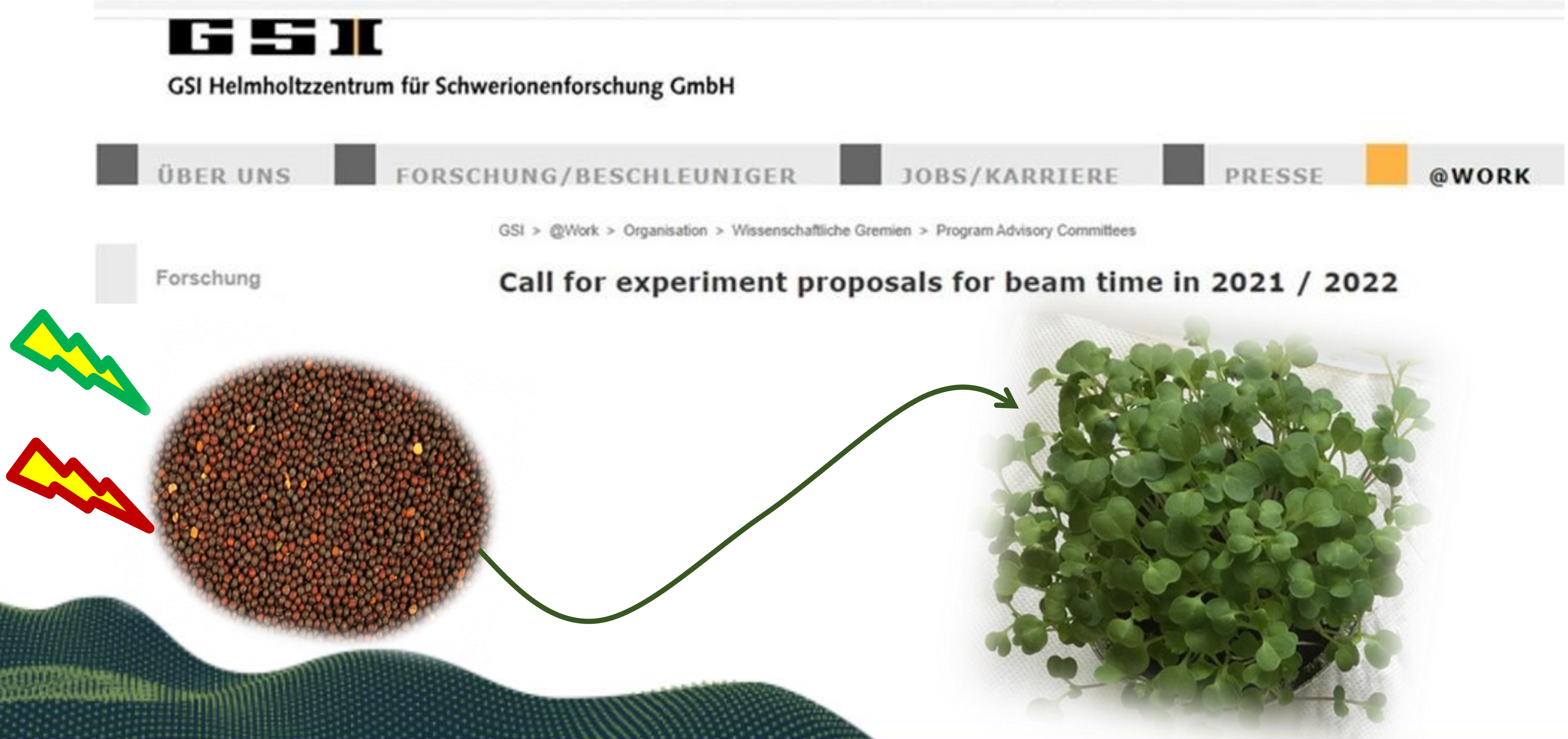
Aim

Effects of **high-LET** (Linear Energy Transfer) ionizing radiation on **morpho-anatomical traits** and **antioxidant content** of *Brassica rapa* L. subsp. *sylvestris* var. *esculenta* microgreens

- Control
- 0.3 Gy
- 1 Gy
- 10 Gy
- 20 Gy
- 25 Gy

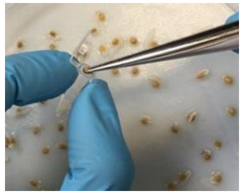
^{12}C

^{56}Fe



Experimental phases and analyses

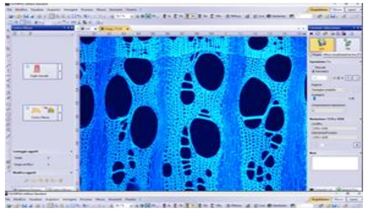
Procedures



Irradiation

Cultivation

Analyses



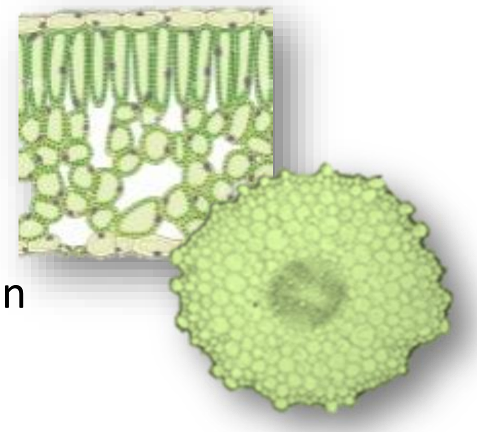
Data elab

Growth and morphology

- ✓ Germination and survival
- ✓ Fresh and dry biomass
- ✓ Hypocotyl length
- ✓ Cotyledon and leaf area

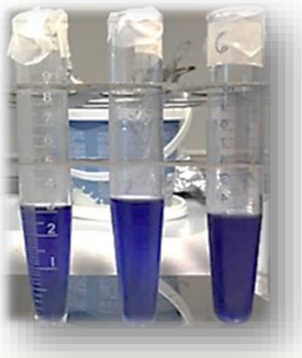
Functional anatomical traits

- ✓ Tissue thickness
- ✓ Tissue density
- ✓ Stomata traits
- ✓ Phenolics localization



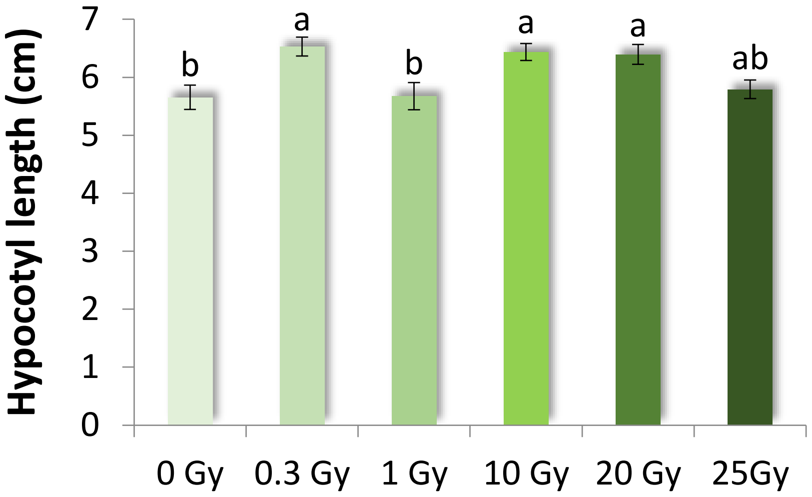
Biochemical traits

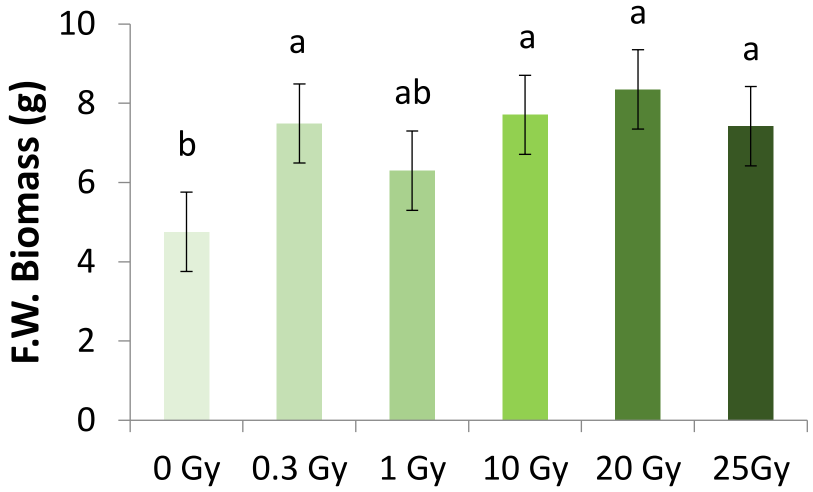
- ✓ Antioxidant capacity
- ✓ Chlorophylls, carotenoids
- ✓ Polyphenols
- ✓ Ascorbic acid
- ✓ Soluble proteins



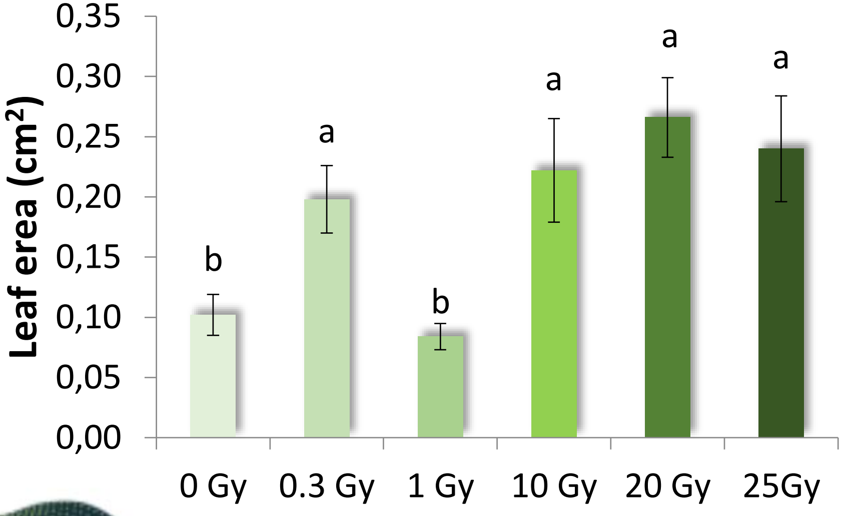
MELiSSA

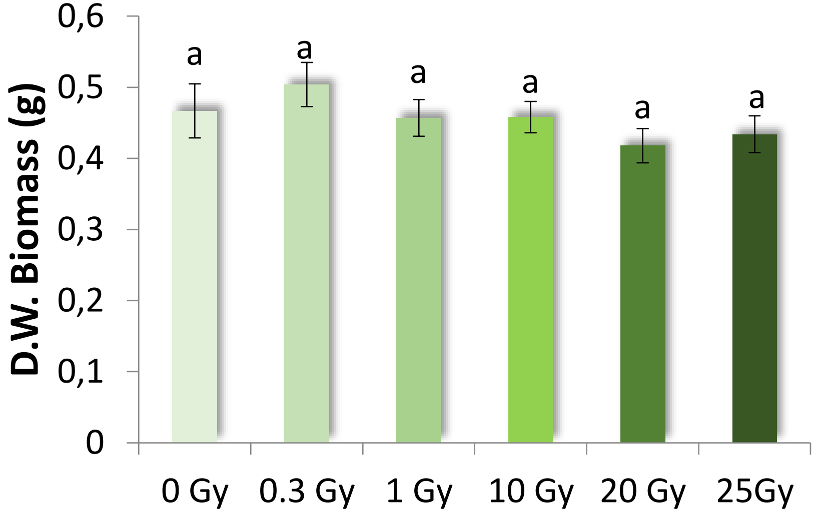
Growth and morphology





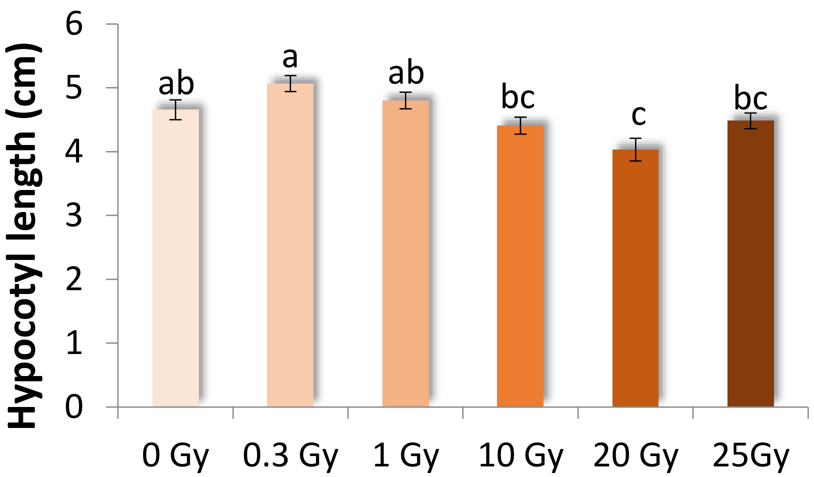
^{12}C

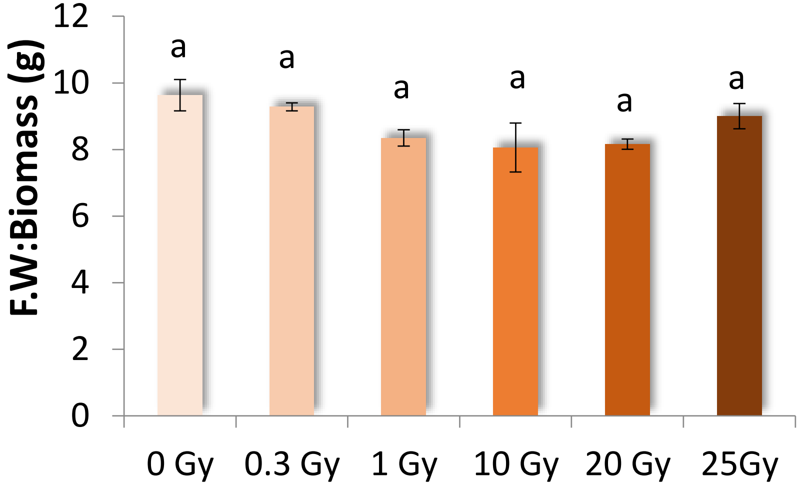


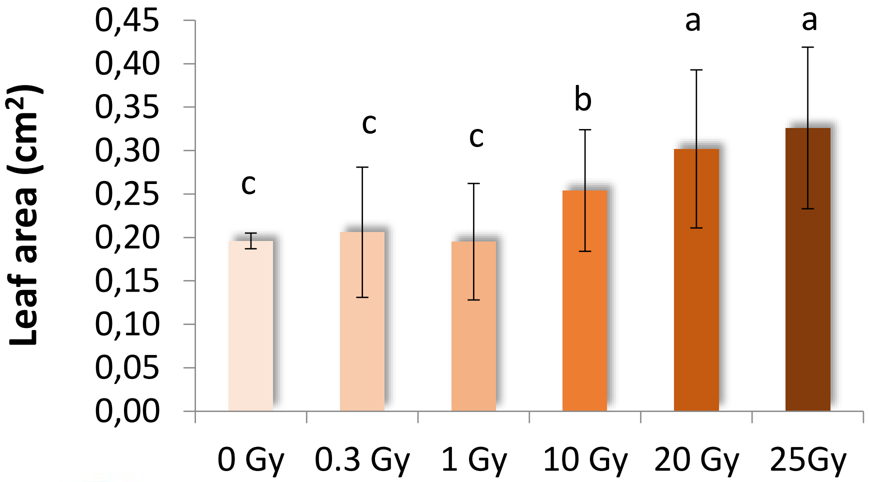


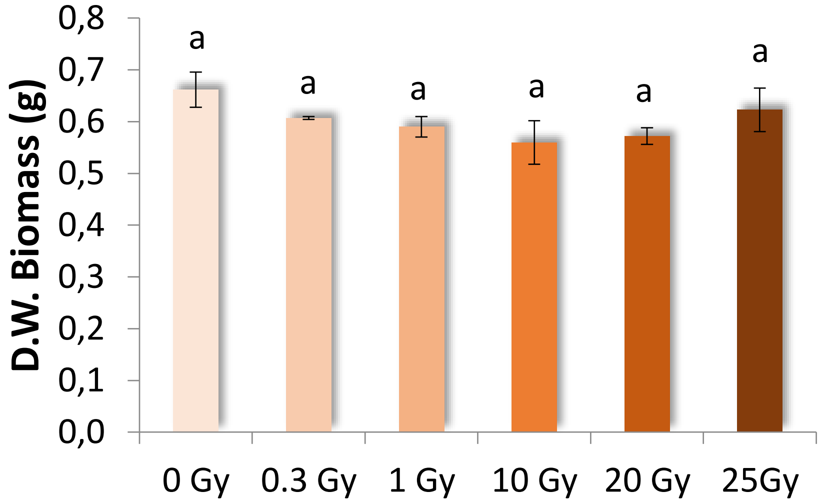
Growth and morphology

^{56}Fe

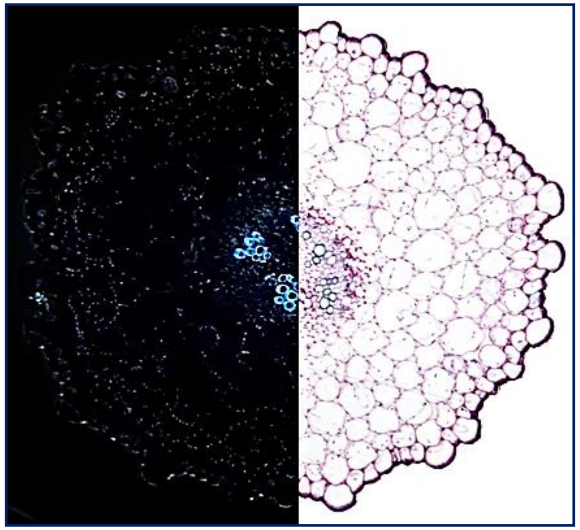


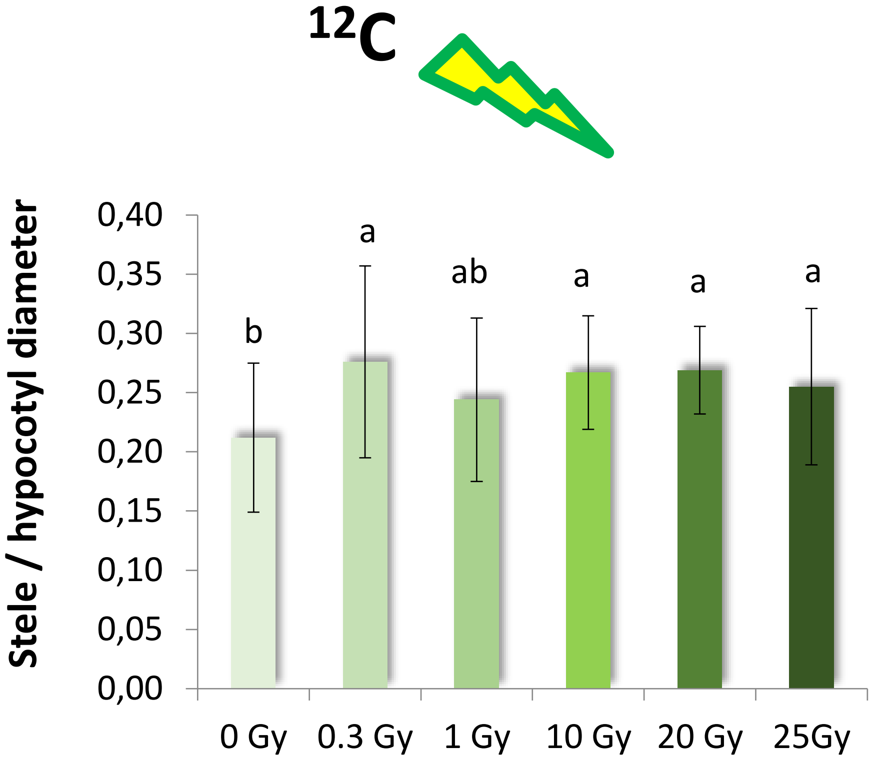




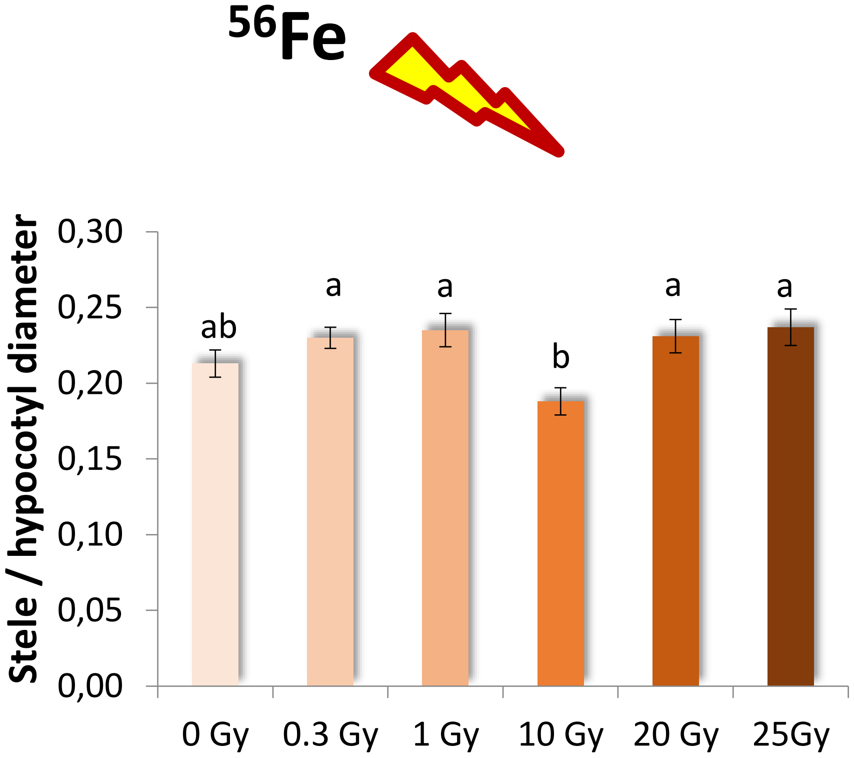


Hypocotyls





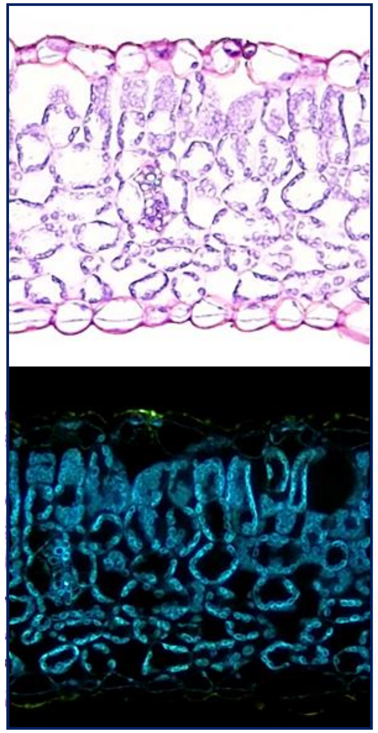
12C
Stele / hypocotyl diameter
0,40
0,35
0,30
0,25
0,20
0,15
0,10
0,05
0,00
b
a
ab
a
a
a
0 Gy
0.3 Gy
1 Gy
10 Gy
20 Gy
25Gy

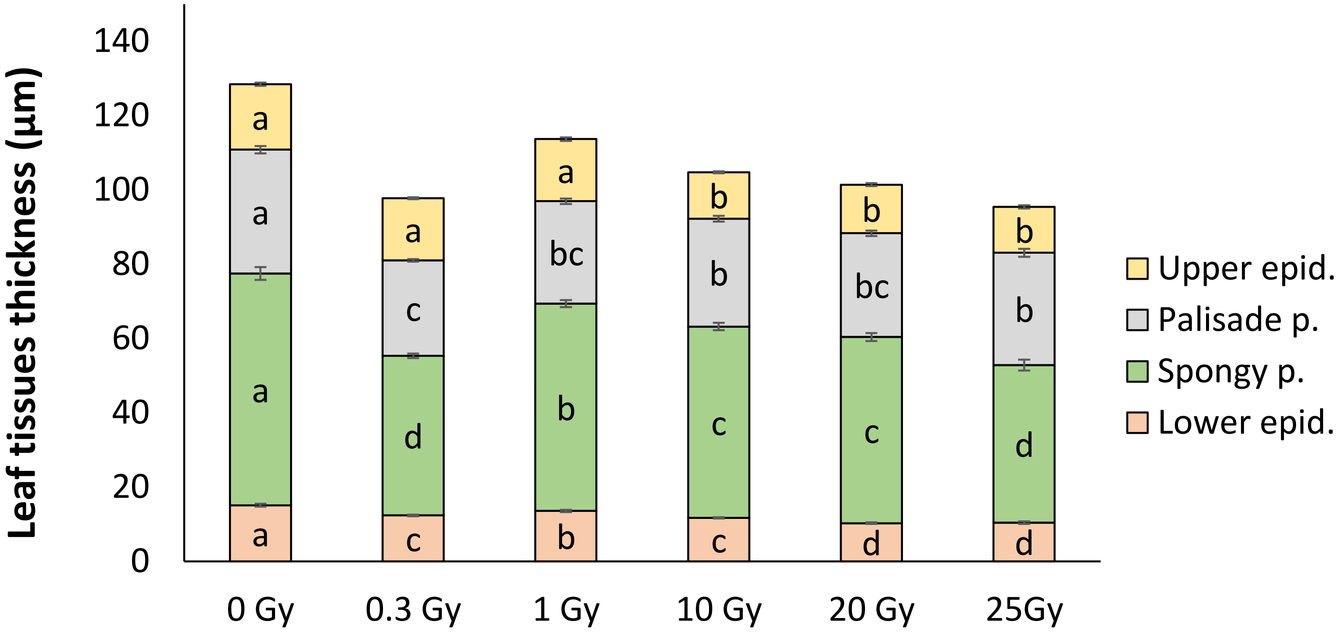


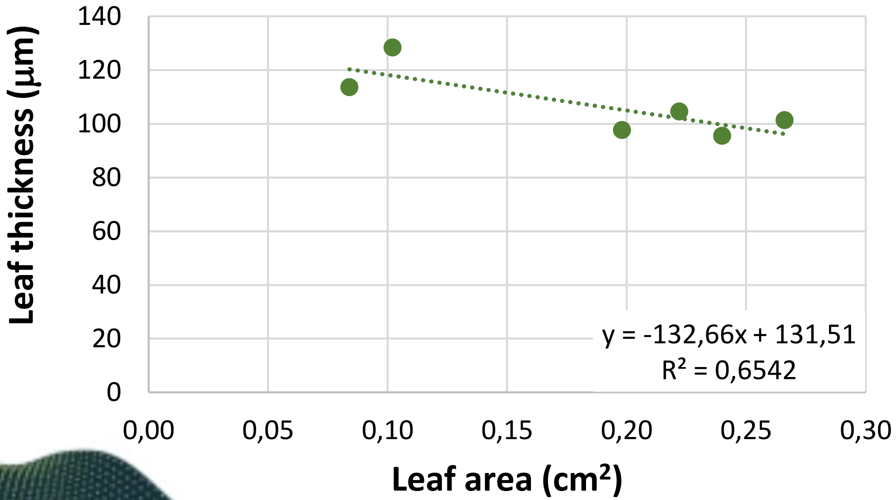
56Fe
Stele / hypocotyl diameter
0,30
0,25
0,20
0,15
0,10
0,05
0,00
ab
a
a
b
a
a
0 Gy
0.3 Gy
1 Gy
10 Gy
20 Gy
25Gy

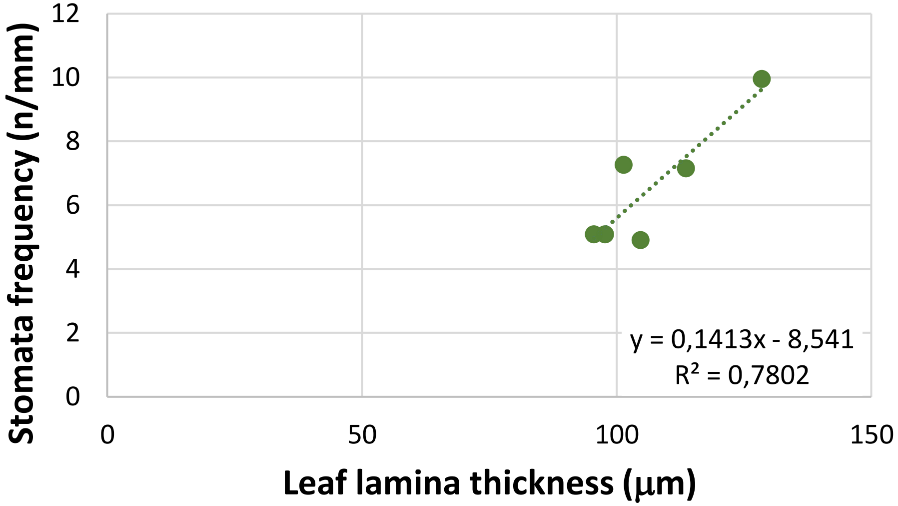
^{12}C

Leaves



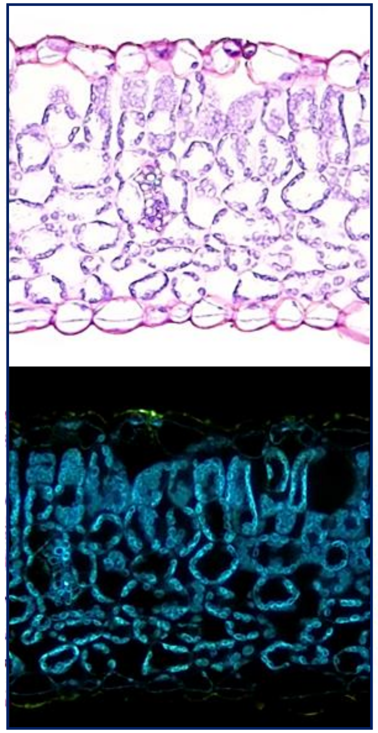

Leaf tissues thickness (µm)
140
120
100
80
60
40
20
0
a a a a
a d c c
a a bc b
a b b c
b c bc c
b d b d
b c b d
0 Gy
0.3 Gy
1 Gy
10 Gy
20 Gy
25Gy
Upper epid.
Palisade p.
Spongy p.
Lower epid.

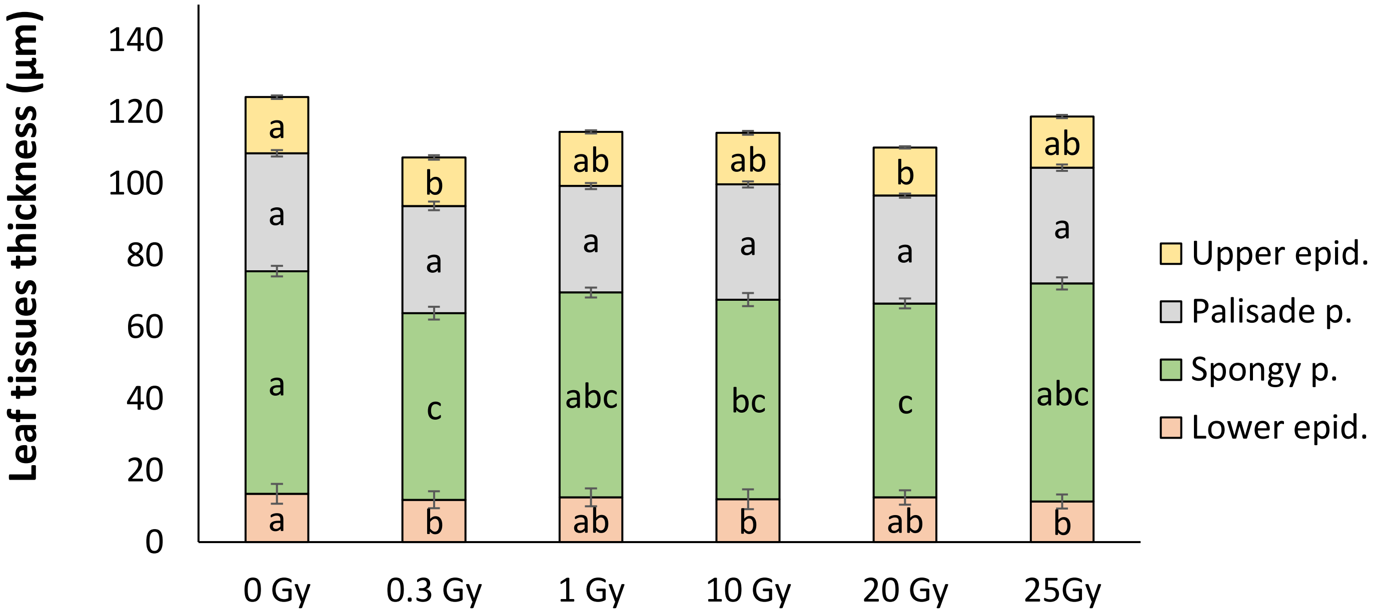

Leaf thickness (µm)
140
120
100
80
60
40
20
0
0,00
0,05
0,10
0,15
0,20
0,25
0,30
Leaf area (cm²)
y = -132,66x + 131,51
R² = 0,6542

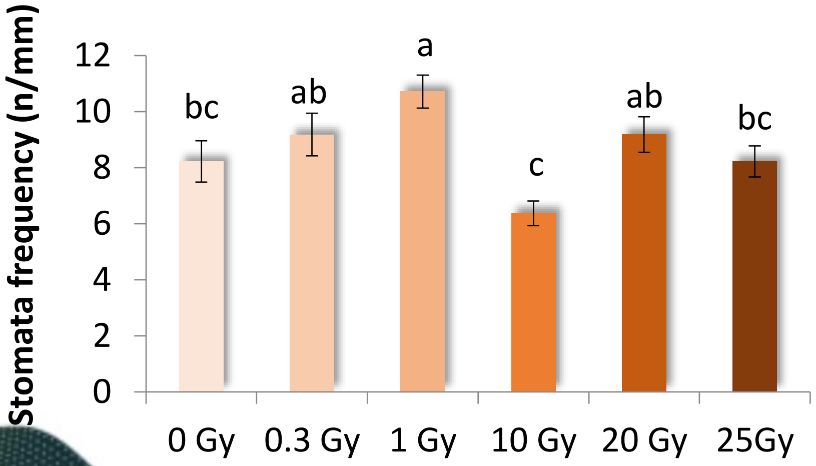

Stomata frequency (n/mm)
12
10
8
6
4
2
0
0
50
100
150
Leaf lamina thickness (µm)
y = 0,1413x - 8,541
R² = 0,7802

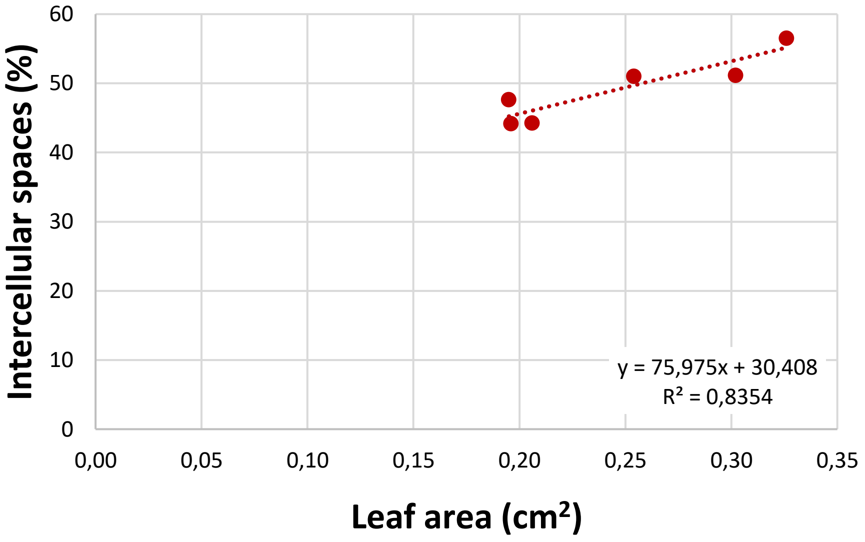
^{56}Fe

Leaves



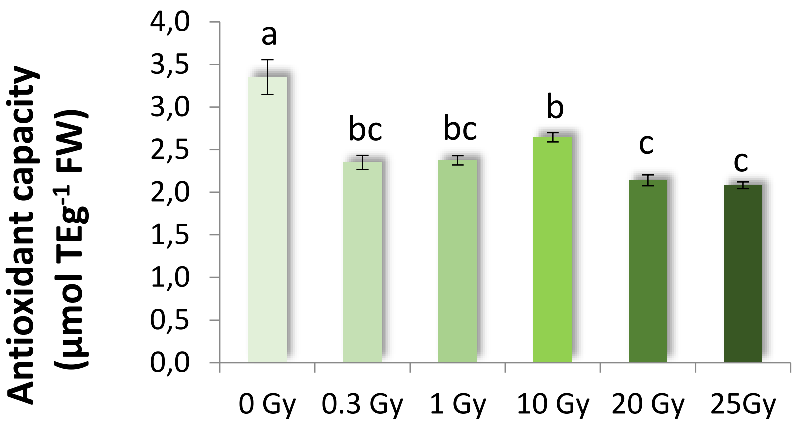

Leaf tissues thickness (µm)
140
120
100
80
60
40
20
0
0 Gy
0.3 Gy
1 Gy
10 Gy
20 Gy
25Gy
Upper epid.
Palisade p.
Spongy p.
Lower epid.
a
b
ab
ab
b
ab
a
a
a
a
a
a
a
c
abc
bc
c
abc
a
b
ab
b
ab
b

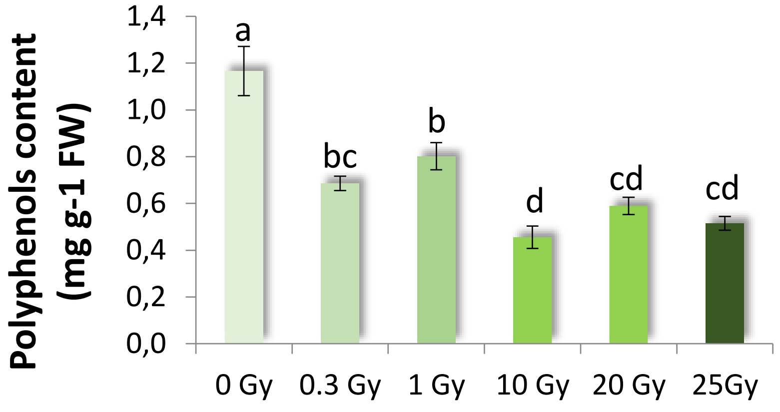

Stomata frequency (n/mm)
12
10
8
6
4
2
0
0 Gy
0.3 Gy
1 Gy
10 Gy
20 Gy
25Gy
bc
ab
a
c
ab
bc

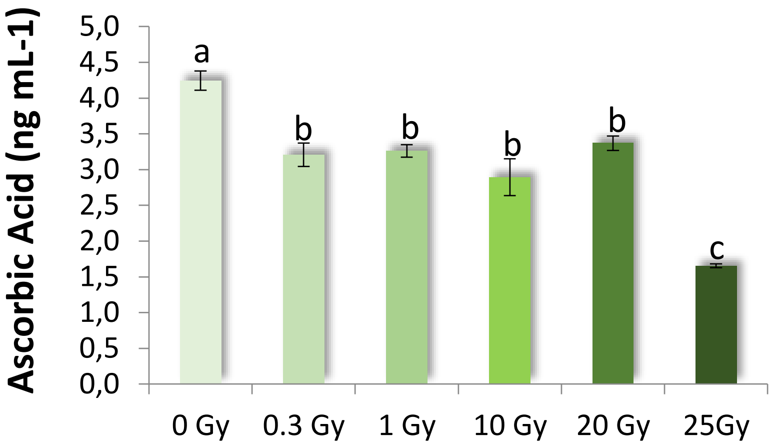

Intercellular spaces (%)
60
50
40
30
20
10
0
0,00
0,05
0,10
0,15
0,20
0,25
0,30
0,35
Leaf area (cm²)
y = 75,975x + 30,408
R² = 0,8354

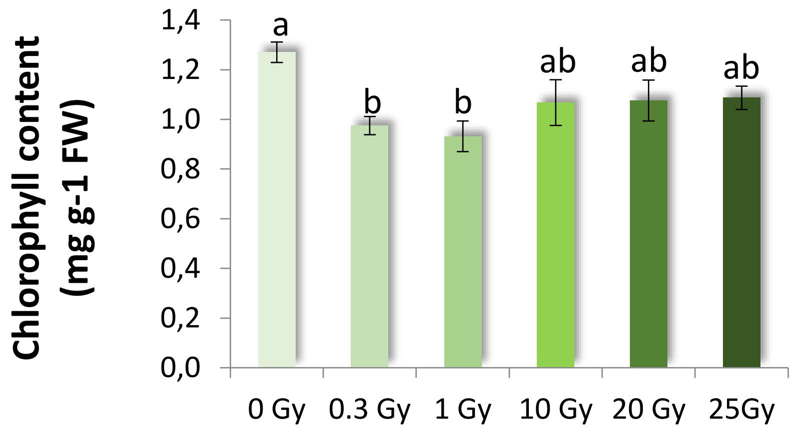
^{12}C

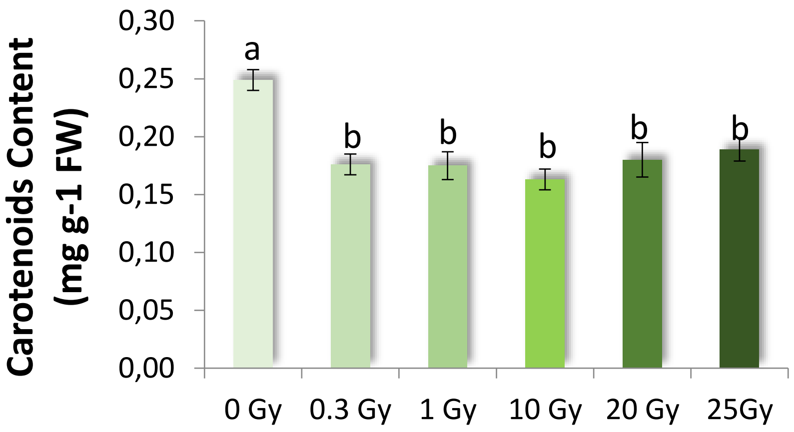
Biochemical traits

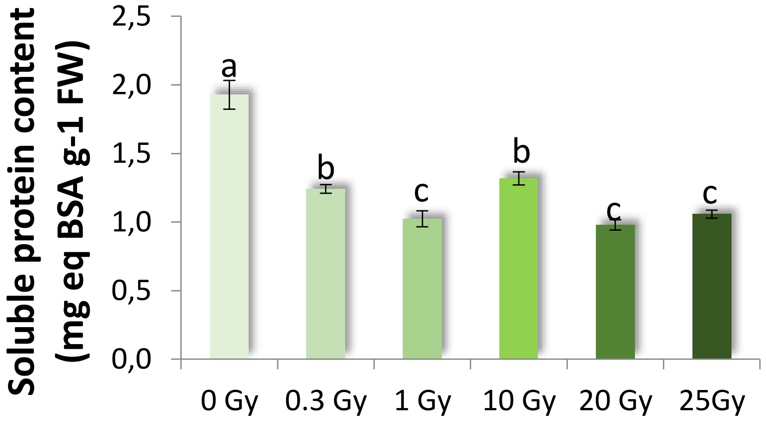






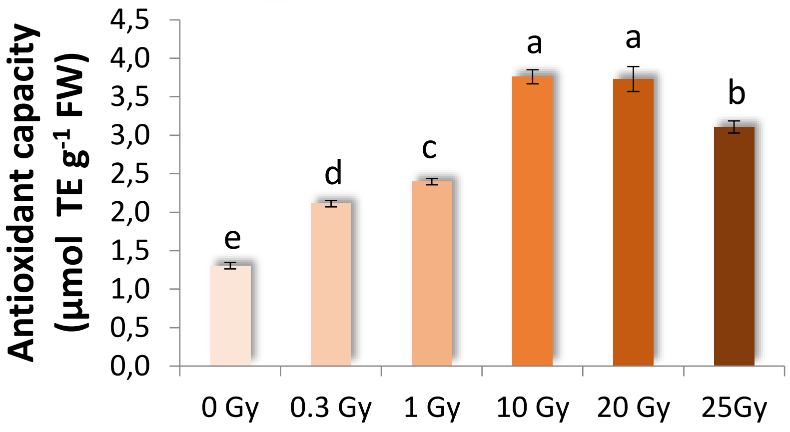


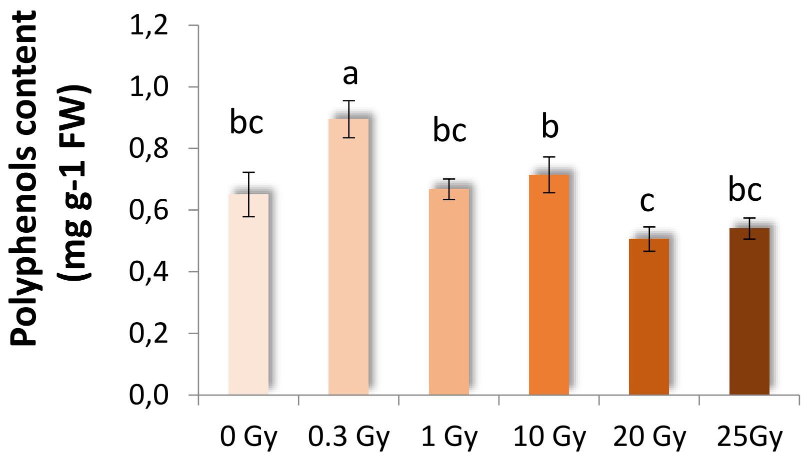


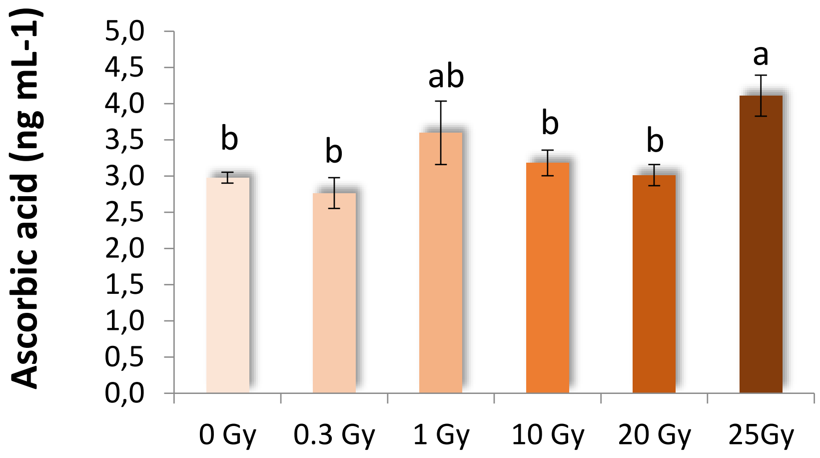


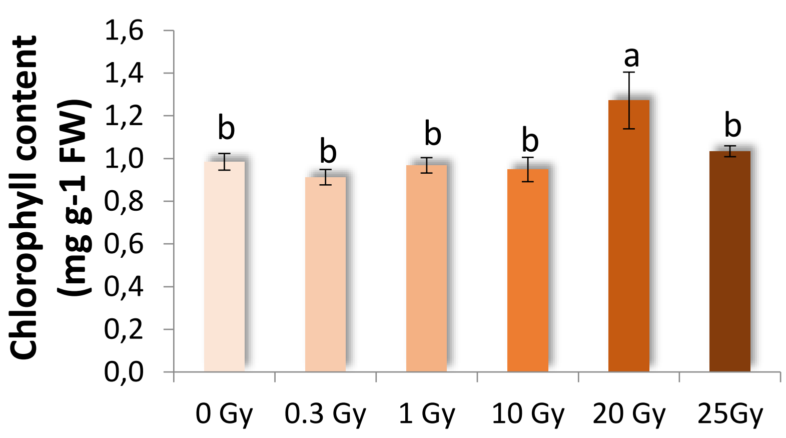
Biochemical traits

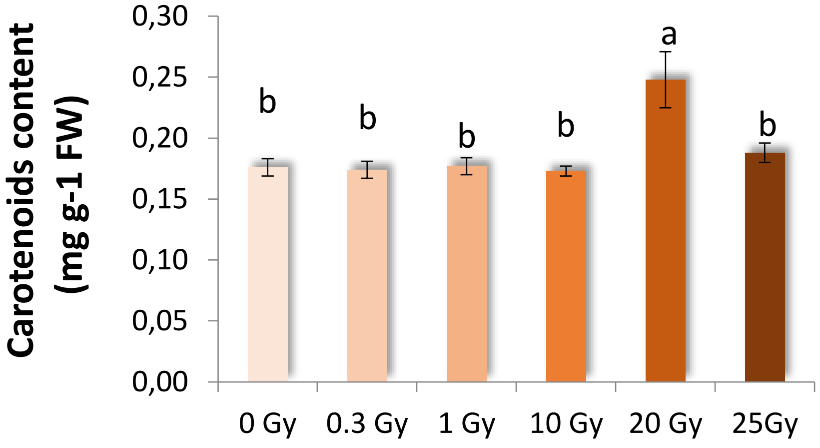
^{56}Fe

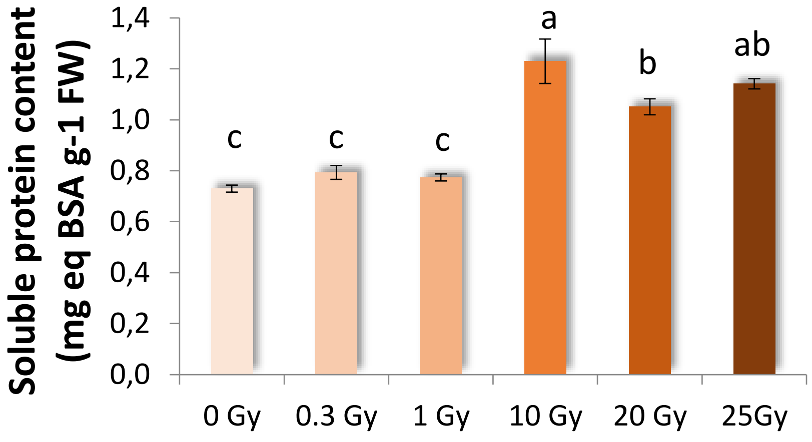






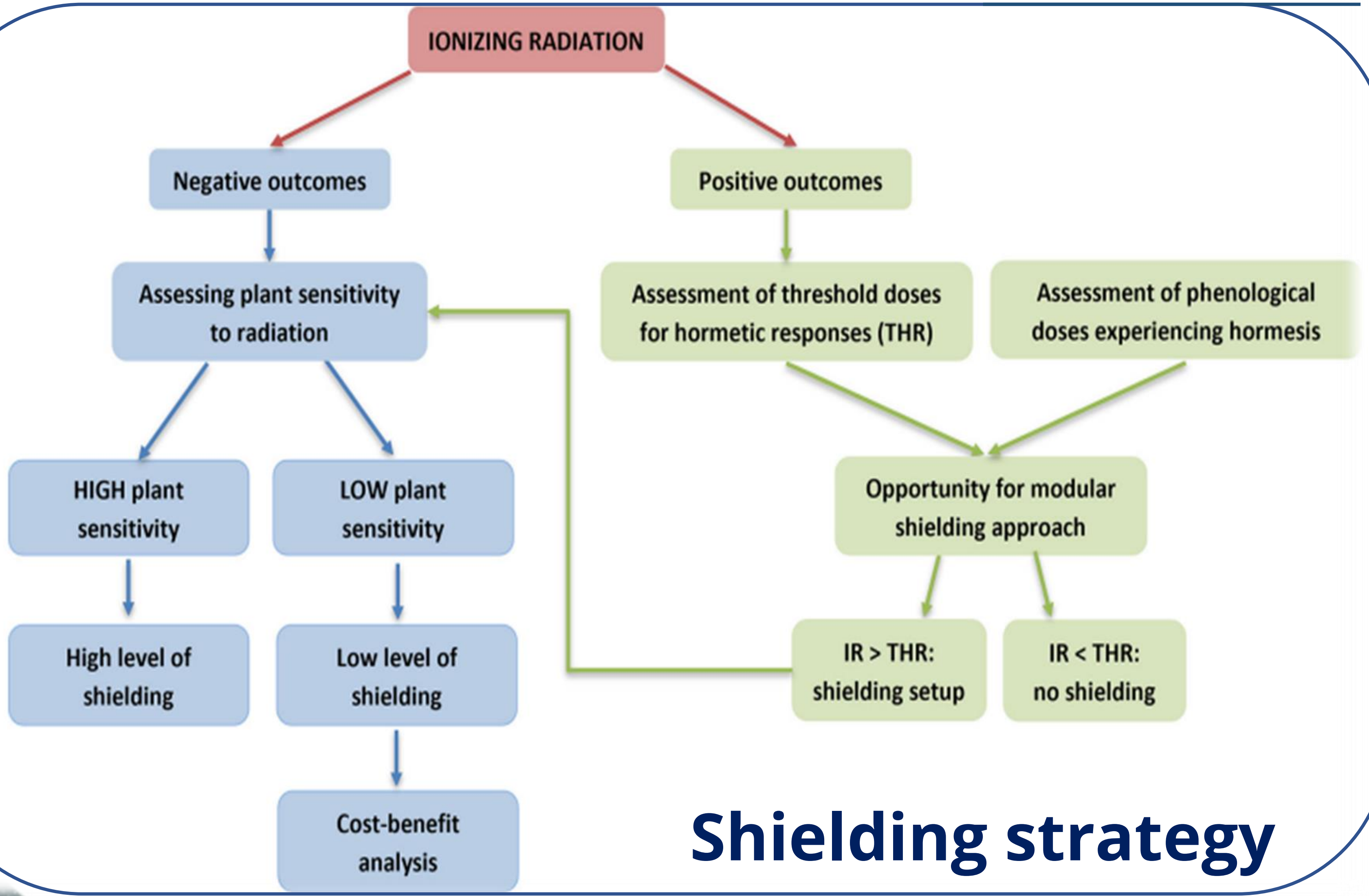






Conclusion

- no aberrations in growth and development
- ion- and dose-specific coordination in morpho-functional traits

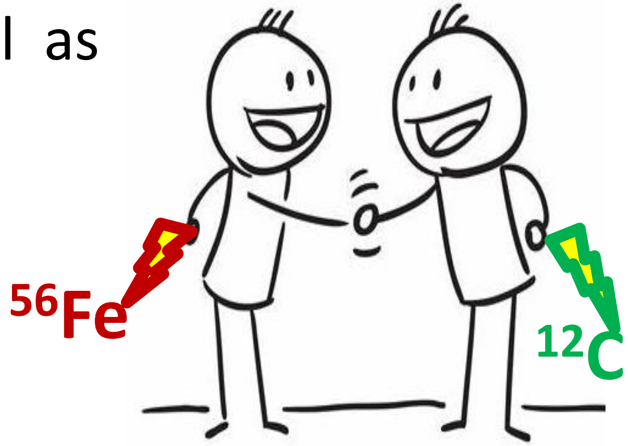


Shielding strategy

De Micco et. al. 2022.
Frontiers Plant Sci Front. Plant Sci. 13:1001158.

Take-home message and further perspectives

- To identify **threshold doses** which maximize nutritional value without biomass loss
- To assess whether the **combined action of several radiation** sources have additional or compensatory effects
- Further experiments using other sources of radiation as well as **galactic cosmic ray simulators** are desirable



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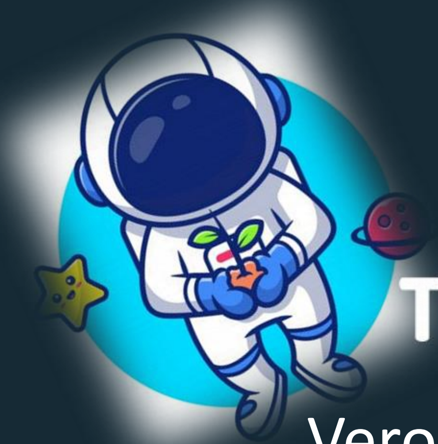

THANK YOU.

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www.melissafoundation.org

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Part of the results presented here is based on the experiment Bio_08_DeMicco, which was performed at the SIS18 at the GSI Helmholtzzentrum fuer Schwerionenforschung, Darmstadt (Germany) in the frame of FAIR Phase-0

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