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CREATING A CIRCULAR FUTURE

Lactuca sativa L. plants showed different capacities to cope with ionizing radiation when exposed to increasing doses of heavy ions

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GSI

Context and Background

Crop production in Space represents one of the greatest challenges for Space exploration since it will be fundamental to regenerate resources in Bioregenerative Life Support Systems (BLSSs), including food, for future Space pioneers.

The integration of fresh vegetables directly produced onboard will be helpful as countermeasure in the diet of humans exposed to Space stressors.

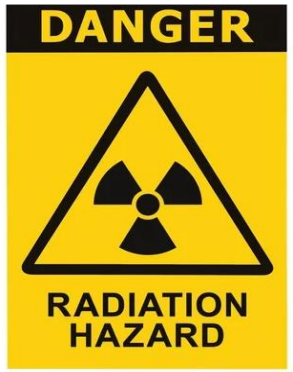
Context and Background

Crop requirements for plant growth in Space:

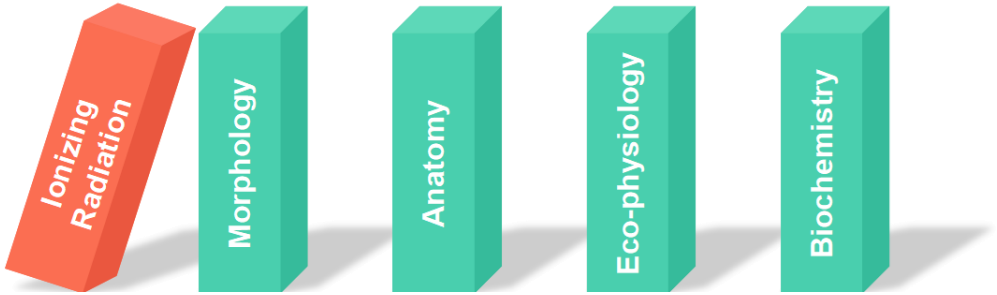
- High **harvest index** (edible dry mass / total dry mass)
- High **Crop efficiency** (per unit area, time, and volume)
- Horticultural **requirements** (planting, harvesting, pollination, processing needs)
- High **nutritional value** (bioactive compounds content)
- Tolerance to **Space factors**

Context and background

It is essential to understand plant behavior when exposed to extraterrestrial environmental factors.

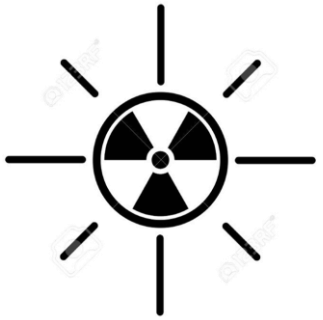


Space ionizing radiation (IR) represents an open issue for mammals but also for plants, being able to induce potential critical outcomes on morpho-anatomical, eco-physiological, and nutritional aspects.



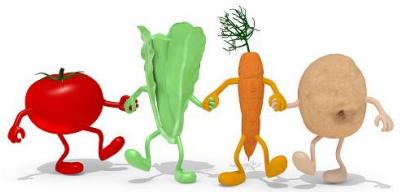
Context and background

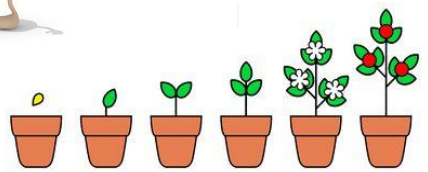
The severity of the effects depends on several factors including:



- radiation-related parameters (e.g. dose, Linear Energy Transfer- LET)

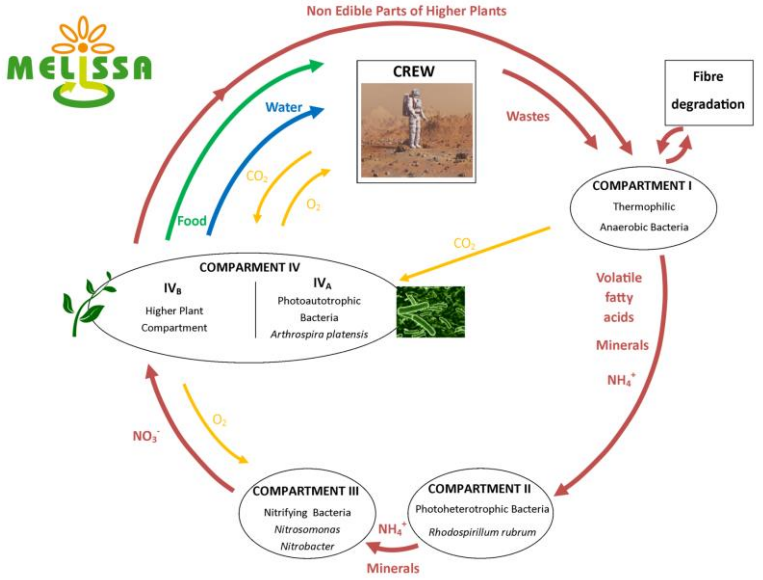
- organism-related traits (e.g. species, cultivar, target organ/tissue, physiological status and structural properties)





Context and background

Understanding how IR may alter plant growth performance is necessary in order to define the requirements for plant cultivation in BLSSs in Space.



Aim

To evaluate the effects of different doses of high-LET (Linear Energy Transfer) radiation on morpho-anatomical and nutritional traits of the Salanova® green cultivar (*Lactuca sativa* L. var. *capitata*).

Study case & experimental design

Dry seeds were exposed to increasing doses (0-control, 0.3, 1, 10, 20, and 25 Gy) of iron ions (^{56}Fe).

Study case & experimental design

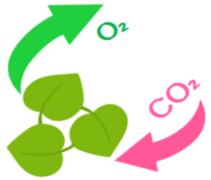
After the irradiation, seeds were sowed, and lettuces were cultivated in a growth chamber under controlled environmental conditions, monitoring growth, morpho-physiological, and biochemical traits.

Performed Analyses

Morphology:

- plant total area
- number of leaves
- fresh and dry biomass

Eco-physiology:



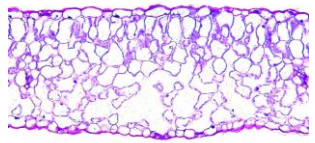
- gas exchanges
- fluorescence of chlorophyll a

Biochemistry:

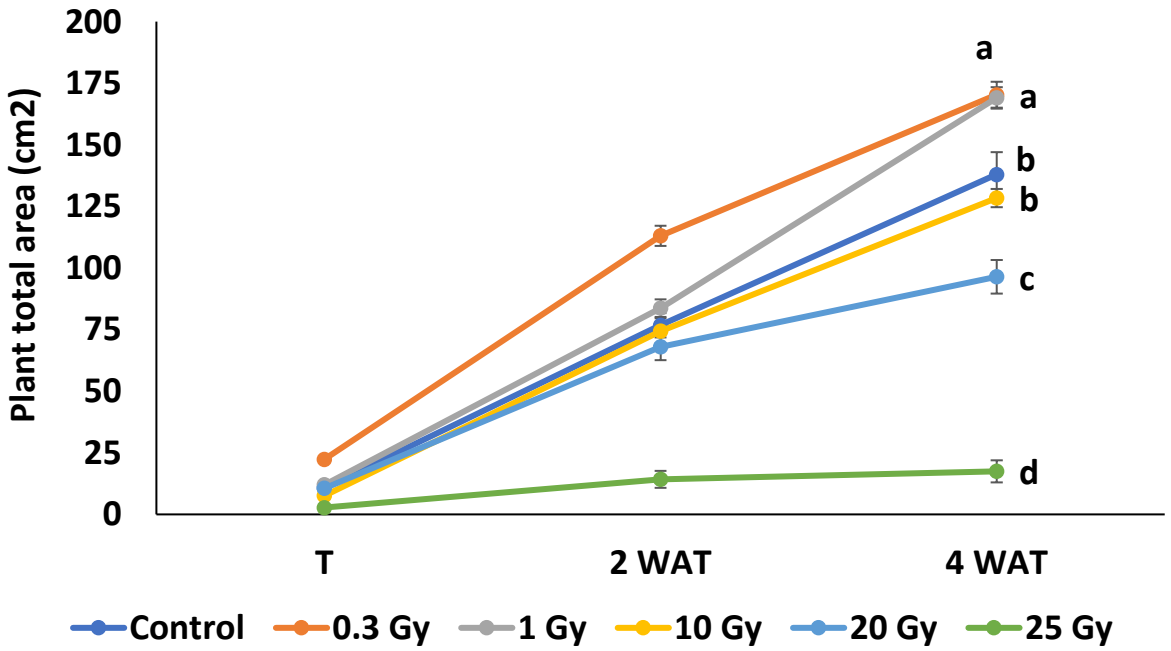
- chlorophyll and carotenoids content
- antioxidant capacity

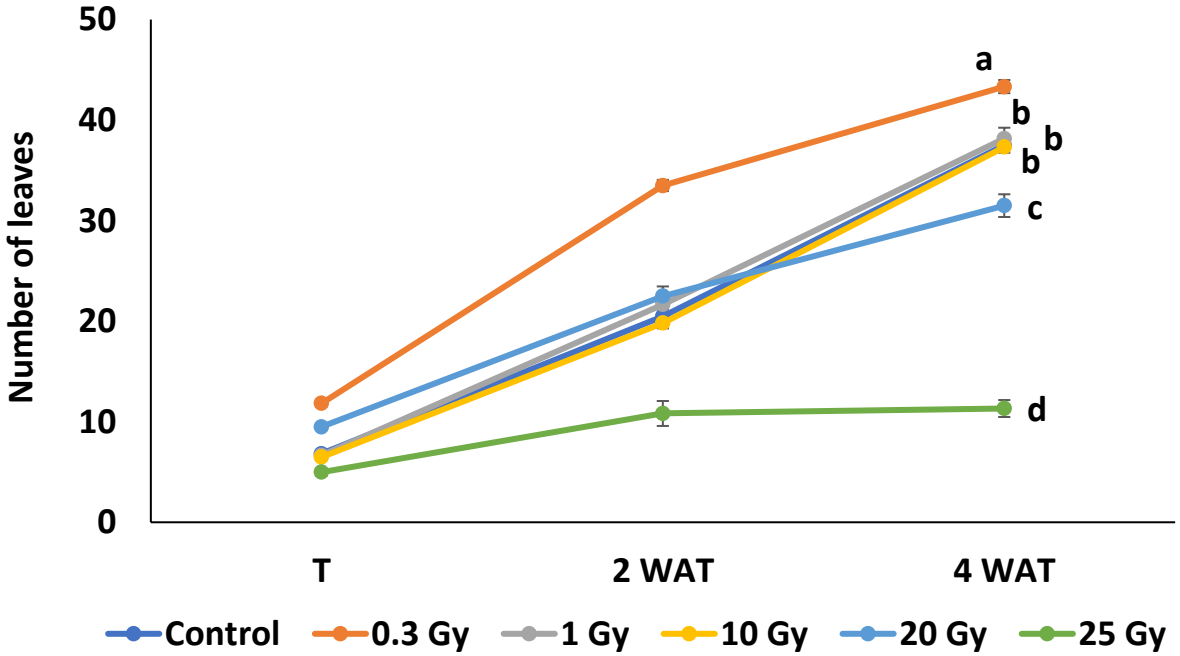
Leaf anatomy:

- tissue characterization
- stomata traits



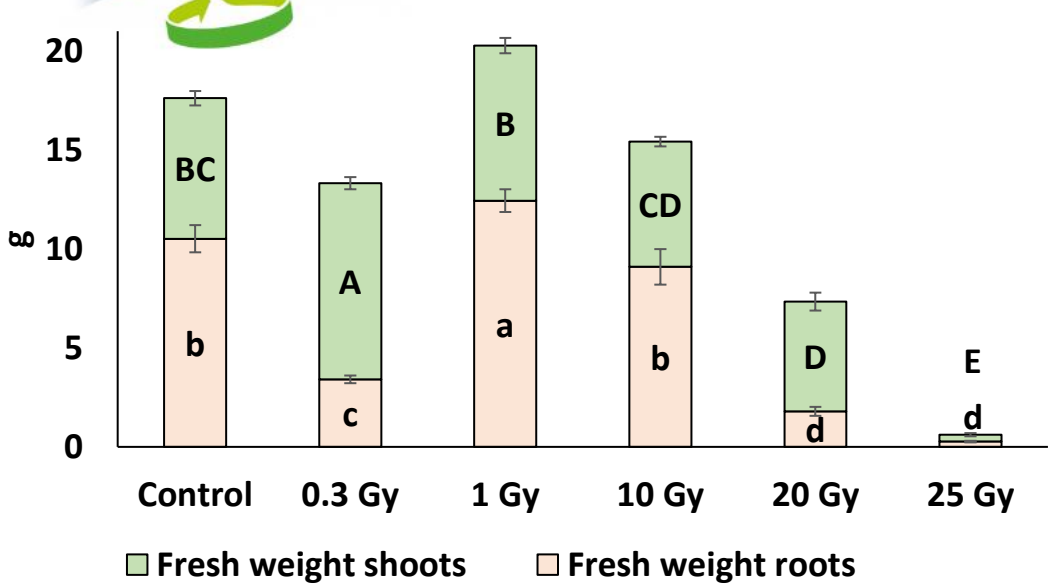
Results: Morphological traits

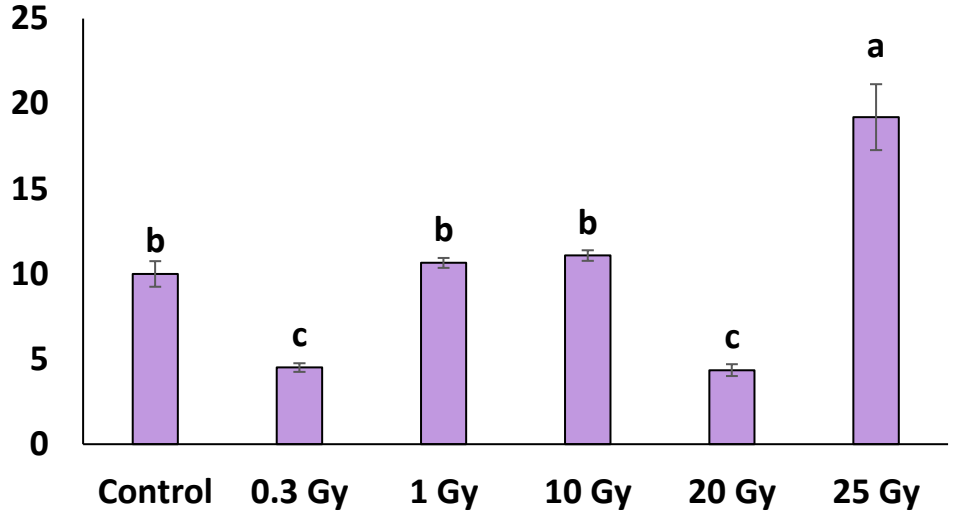


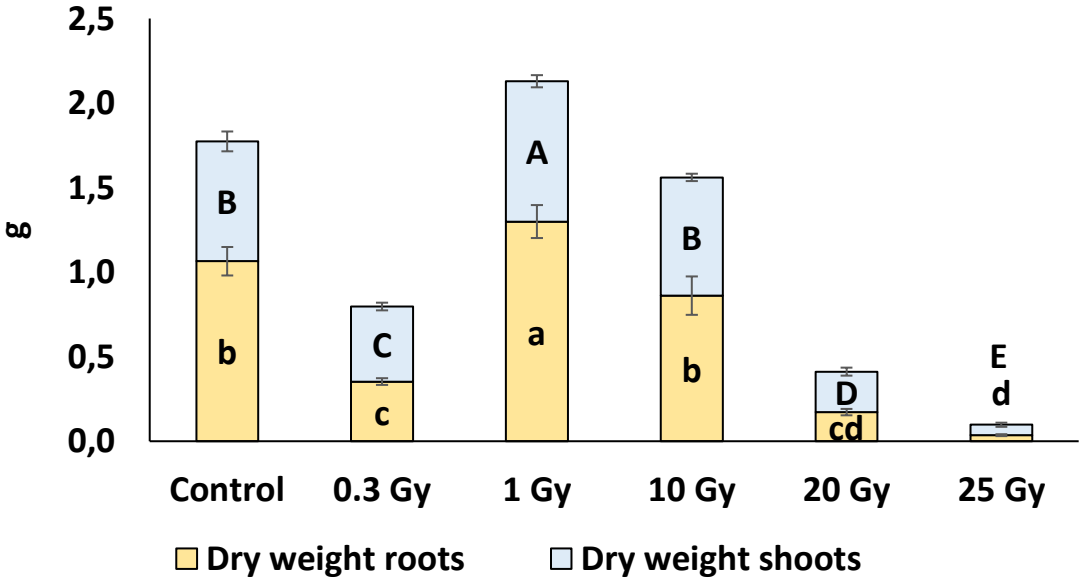


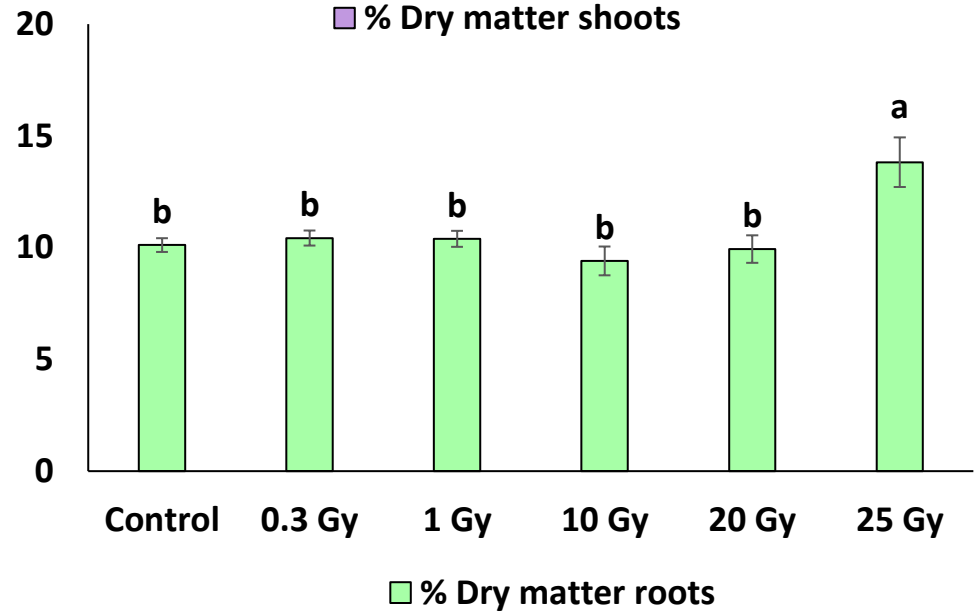
T = transplant
2 WAT = 2 week after transplant
4 WAT = 4 week after trasplant

Morphological traits

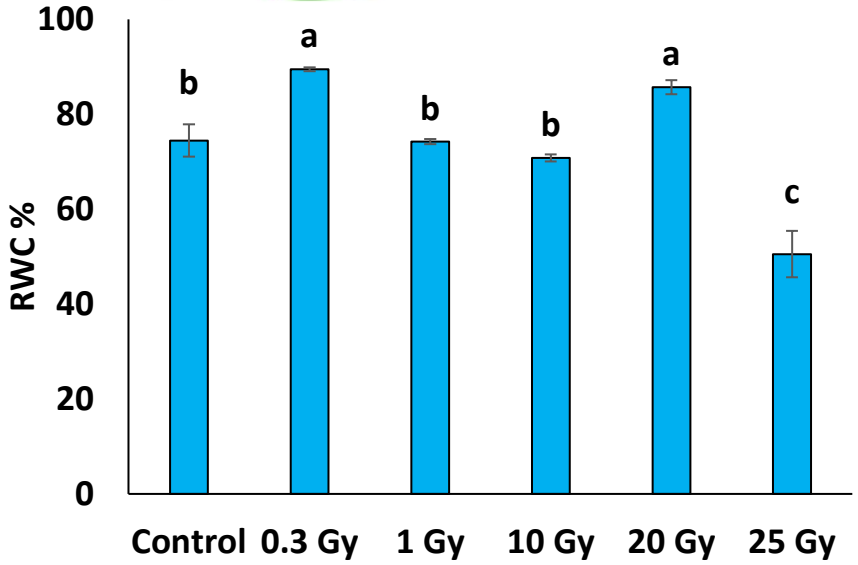


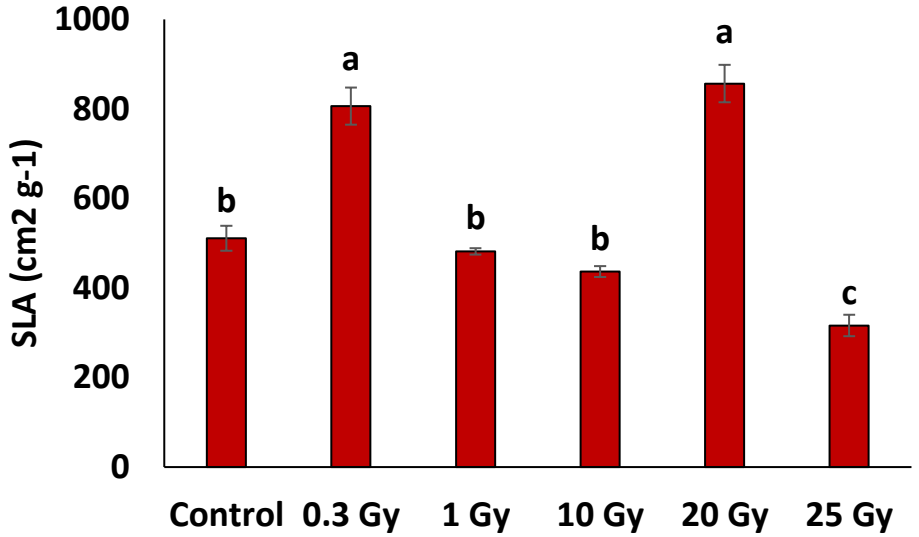


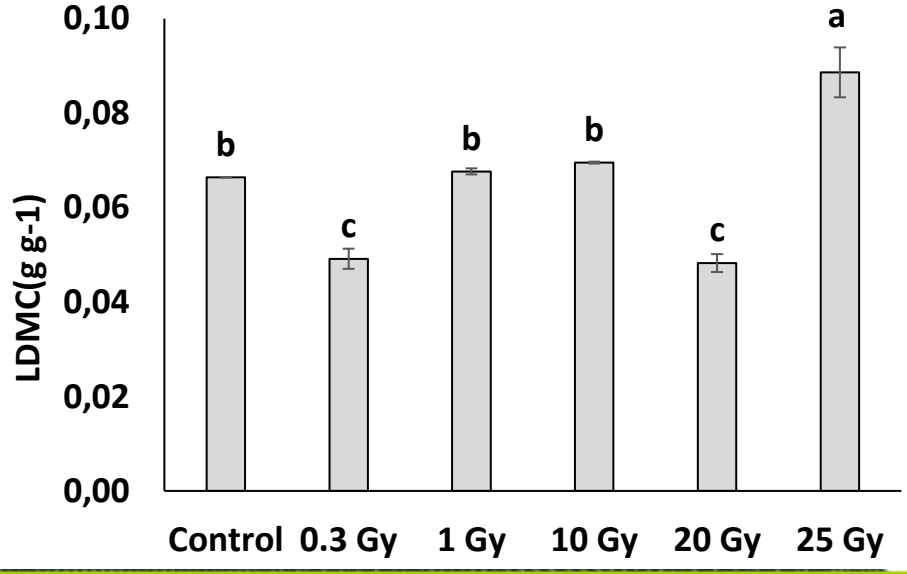




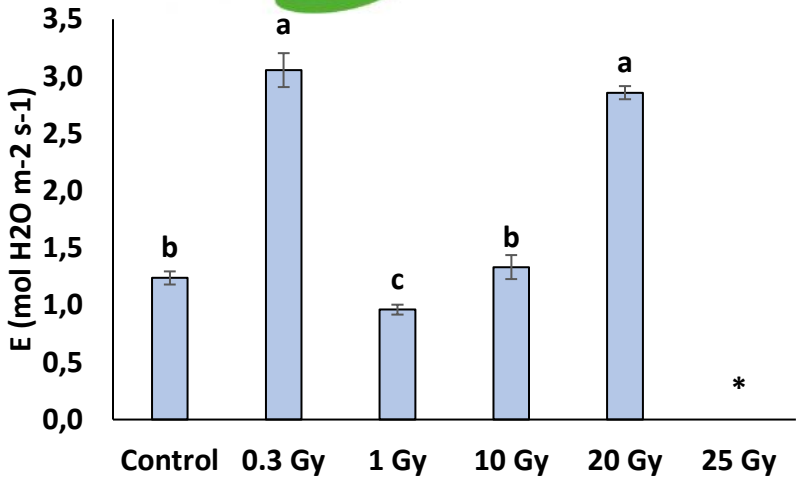
Functional leaf traits

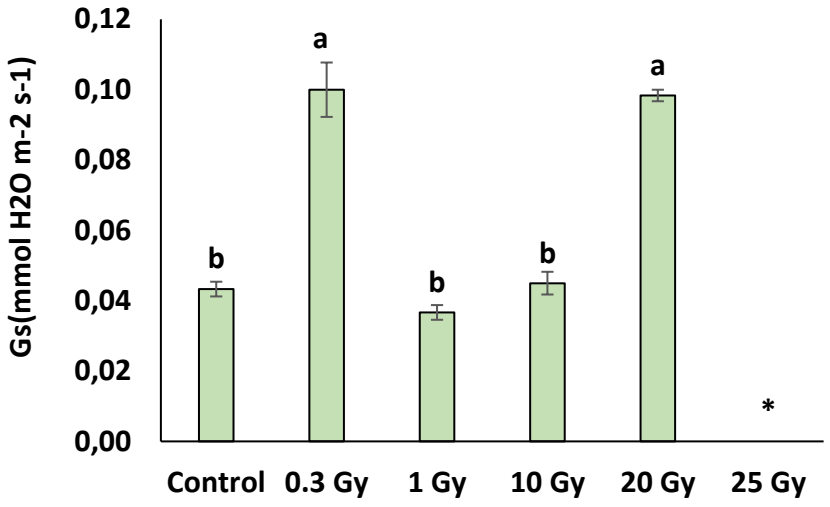


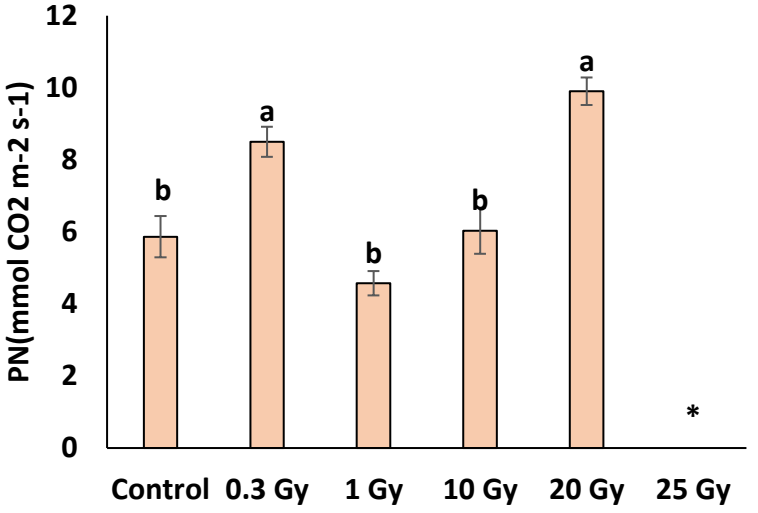


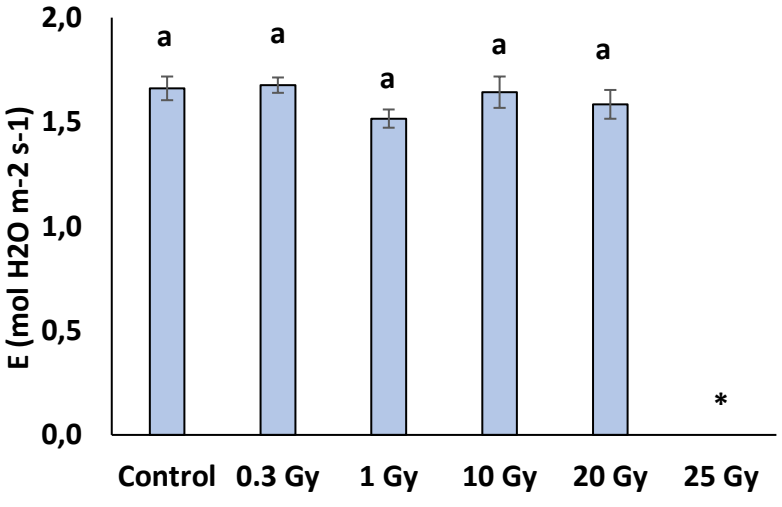


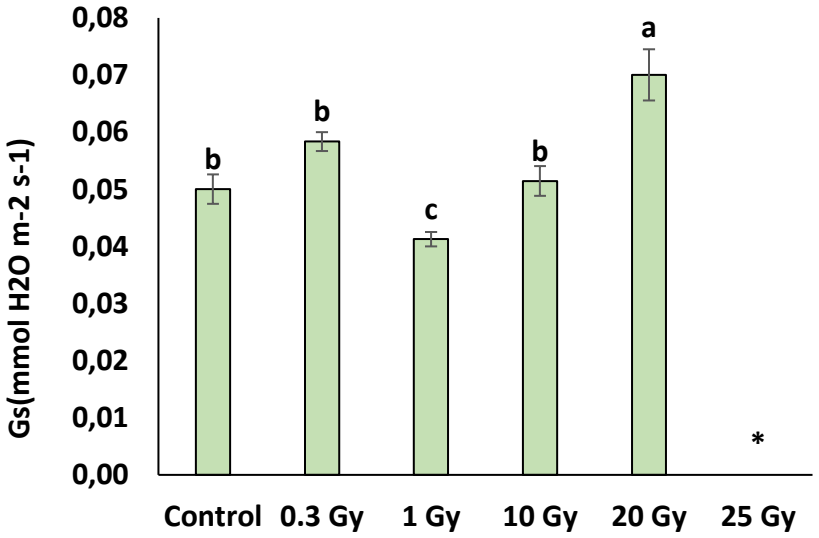
Photosynthesis – Gas Exchanges

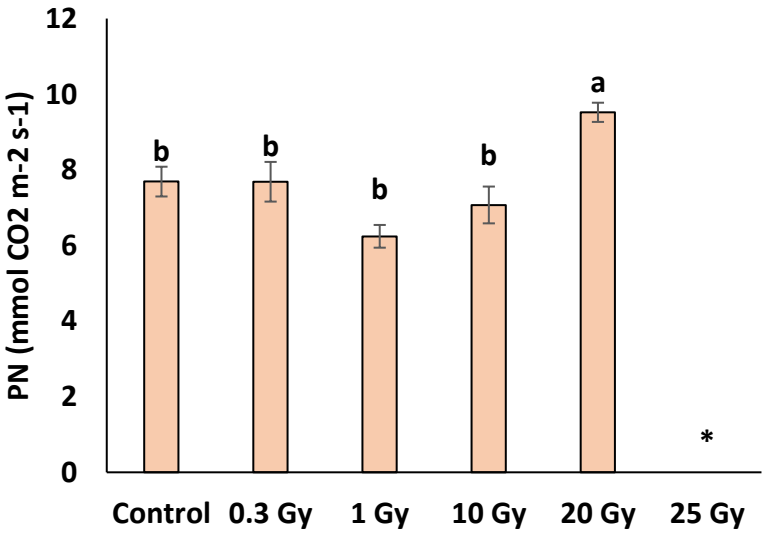






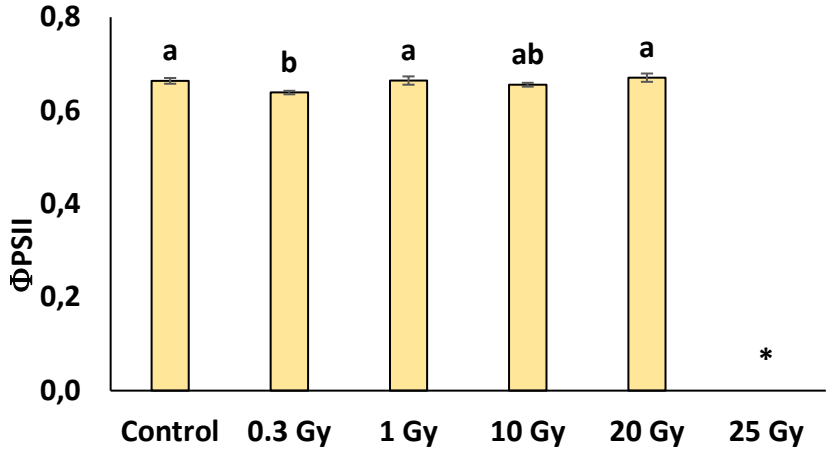


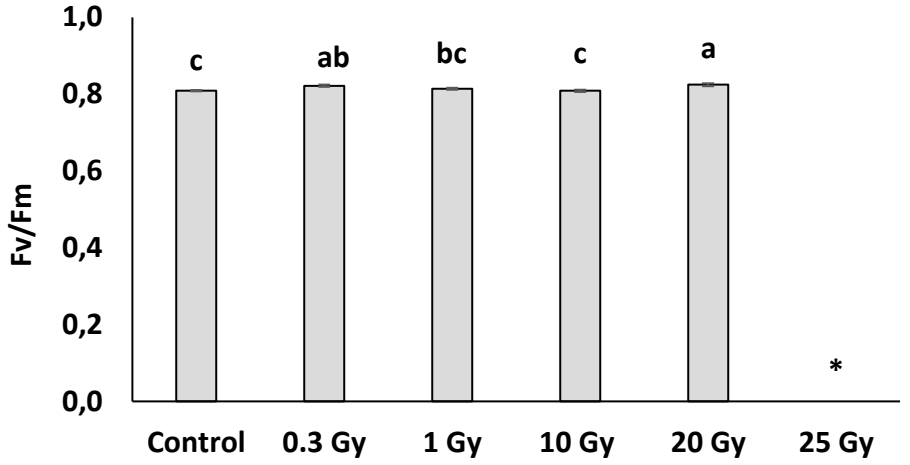


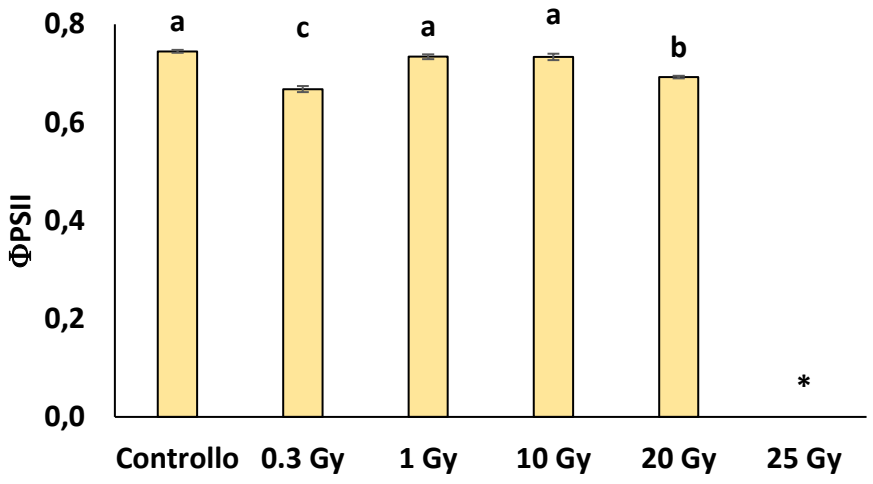


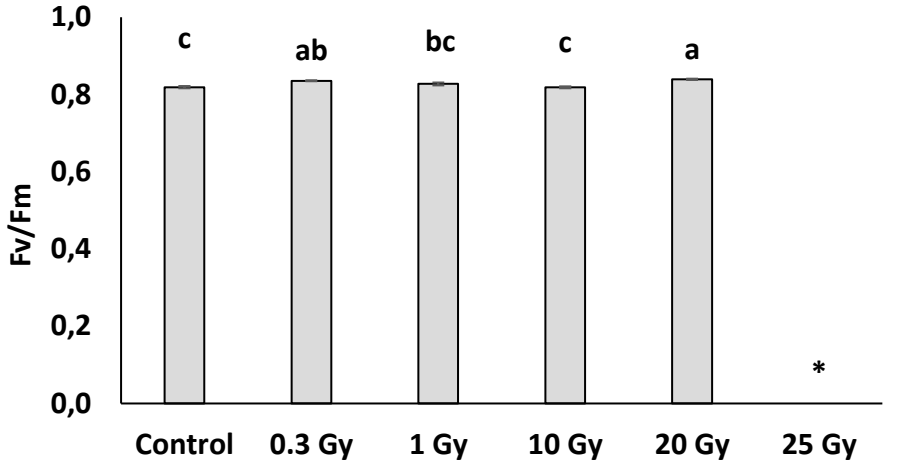
*** not measurable**

Photosynthesis – Chlorophyll Fluorescence



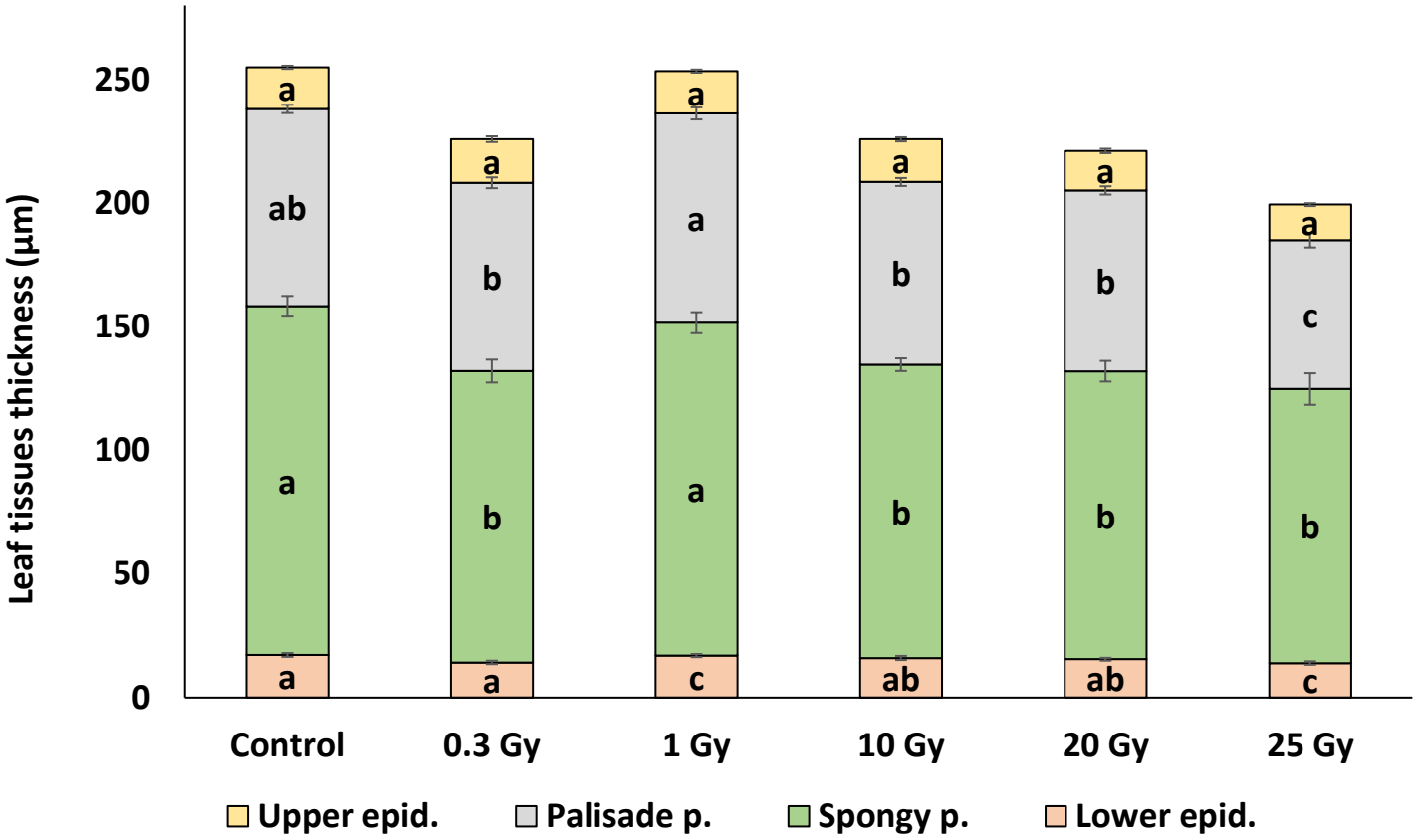




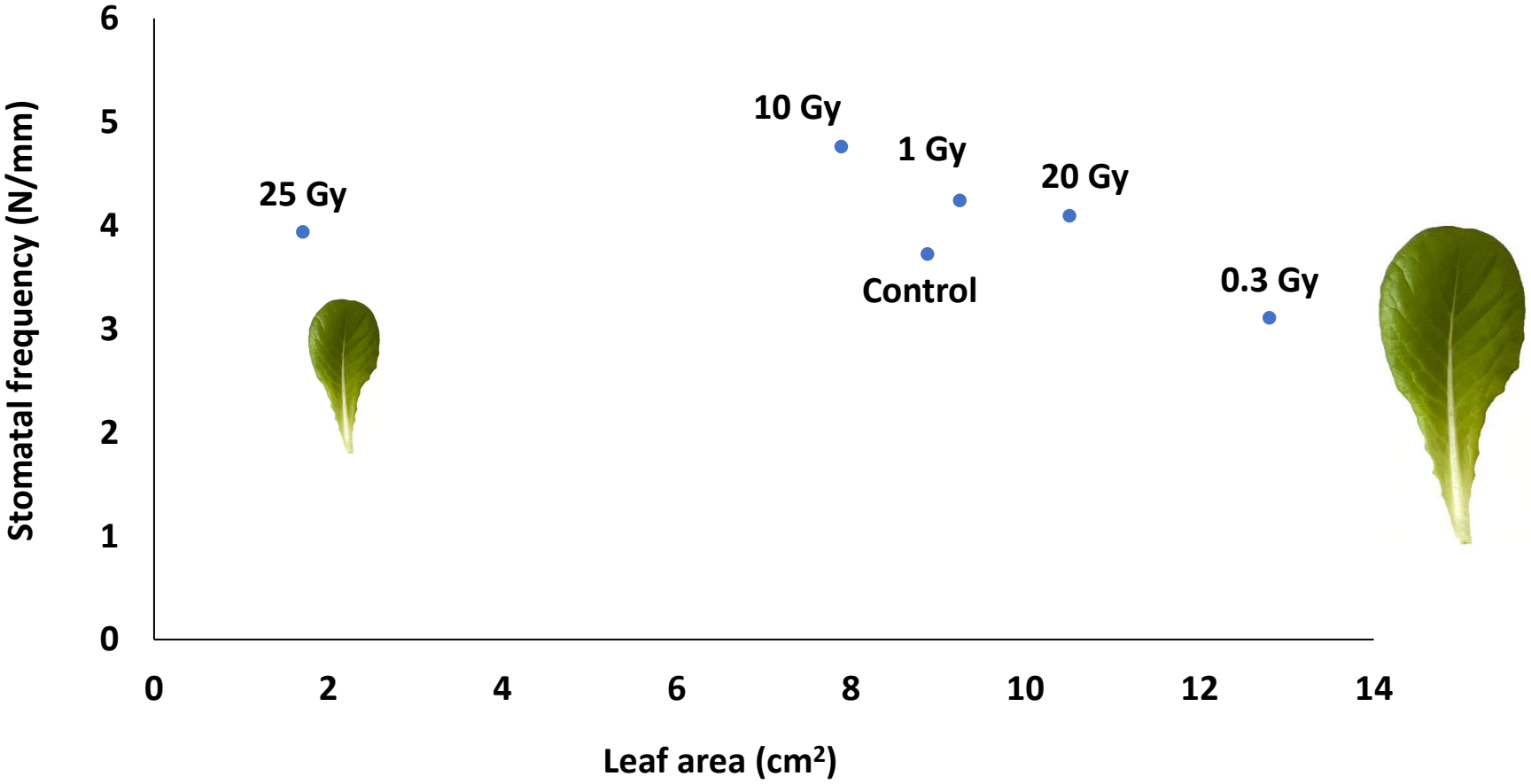


* not measurable

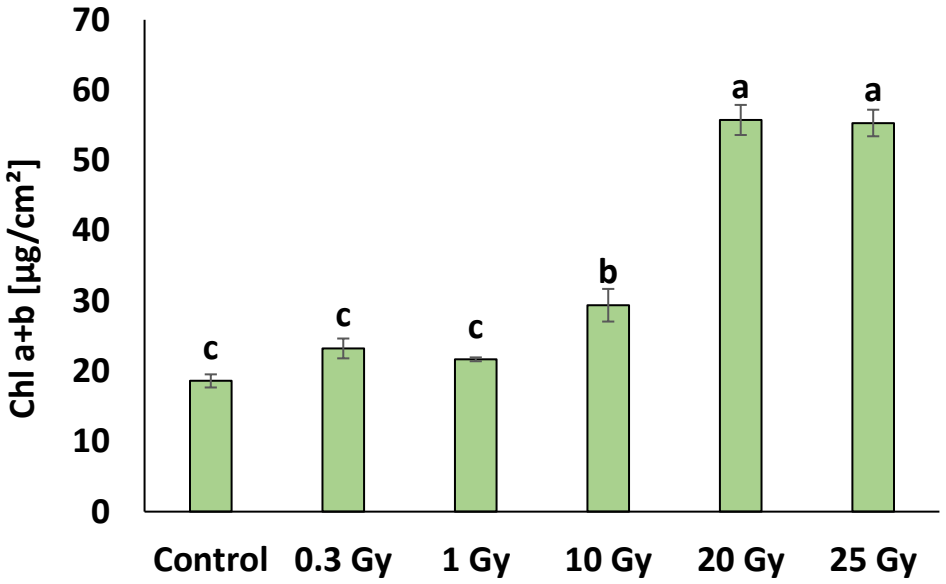
Leaf anatomical traits

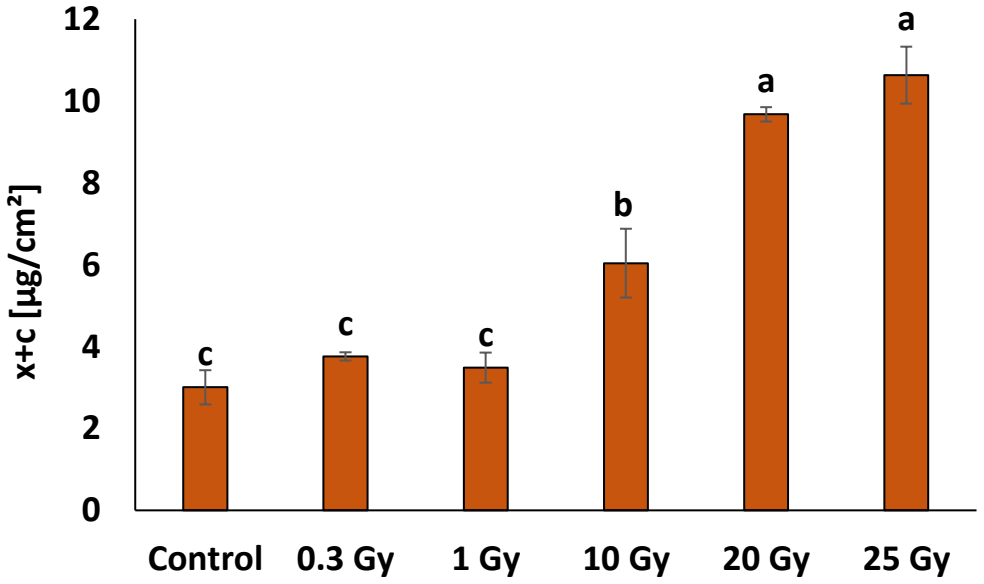


Leaf anatomical traits

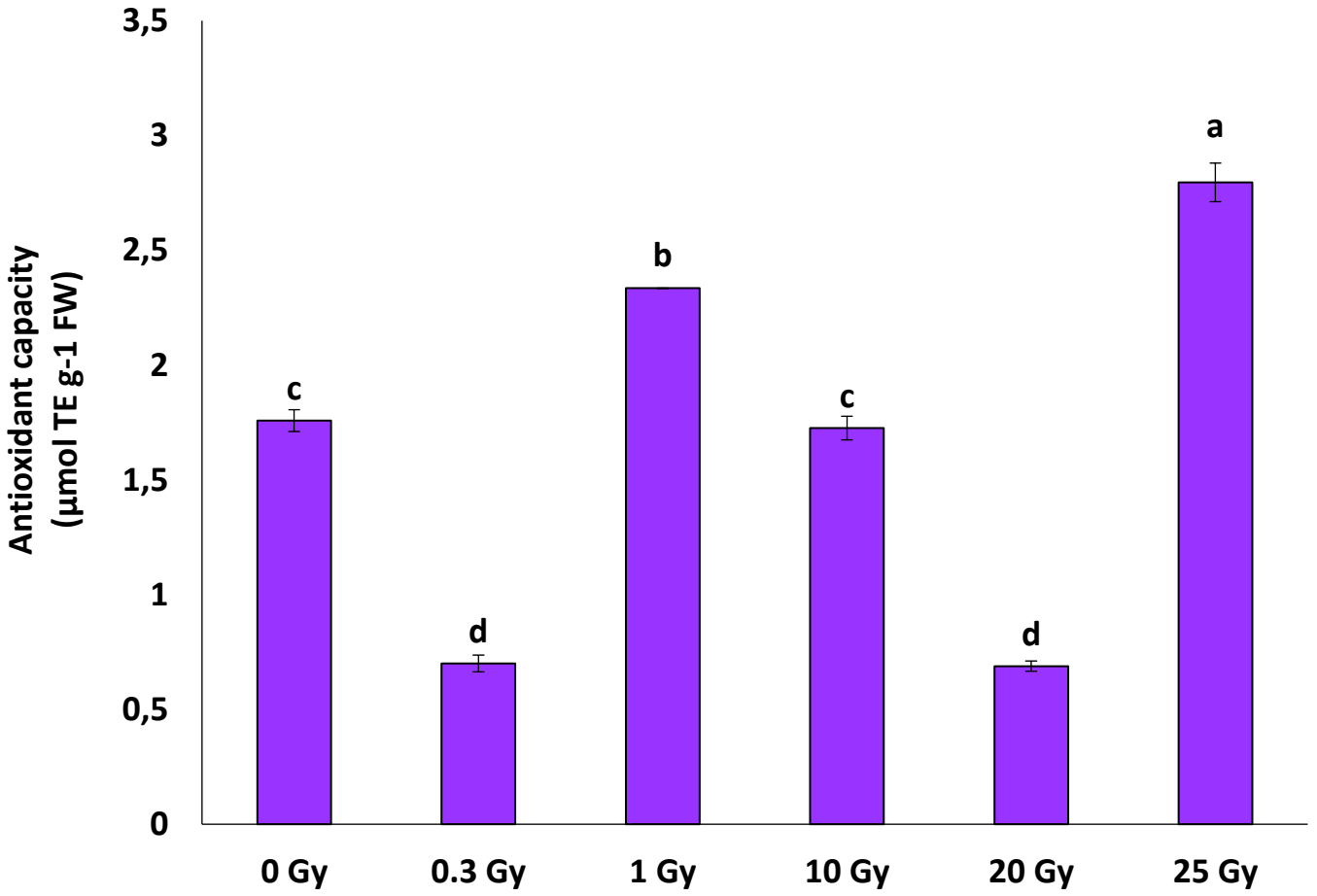


Pigment Content





Antioxidants



Conclusion

The response of *Lactuca sativa* L. plants to radiation changes according to the **dose**.

- ✓ **Morphological** analyses → **0.3 Gy** ↑ stimulatoty effect on plant **growth**
  - **25 Gy** ↓ early **senescence**
- ✓ **Eco-physiological** analyses → **0.3** and **20 Gy** ↑ improve **E, Gs** and **PN**
- ✓ **Anatomical** analyses → no detrimental alteration up to **20 Gy**

Conclusion

✓ **Biochemical** analyses → **25 Gy** ↑ improves **chlorophylls, carotenoids,** and **antioxidant capacity**

→ **20 Gy** ↓ reduces **antioxidants** while ↑ increasing **chlorophylls** and **carotenoids** content**:** *is it a radioprotective strategy???*

Acknowledgments

- The Italian Space Agency (ASI)

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