Current and future ways to Closed Life Support Systems
Joint Agrospace-MELISSA Workshop
Rome May 16 -18 2018

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

Arena C.[1]*, Vitale E.[1], Hay Mele B.[2], Cataletto P.R.[1], Turano M.[1], Simoniello P.[3], De Micco V.[2]

[1]Department of Biology, University of Naples Federico II, Italy; [2]Department of Agricultural and Food Sciences, University of Naples Federico II, Italy; Department of Science and Technology, University of Naples Federico II, Italy
*carmen.arena@unina.it

INTRODUCTION

Plant cultivation in space represents a challenge for the scientists because, in extraterrestrial environments, plants experience altered gravity and ionising radiation that may profoundly affect growth and development [1]. Generally, plant response to ionising radiation depends on dose, ranging from irreparable damage at high doses to stimulatory effects at low levels [2, 3].
This study aimed to assess if non-lethal doses of heavy ions, namely C 25 Gy, delivered at the seed stage, may induce positive outcomes on *Solanum lycopersicum* L. cv 'Microtom' enhancing photosynthesis and promoting favourable traits in fruits (Fig. 2).

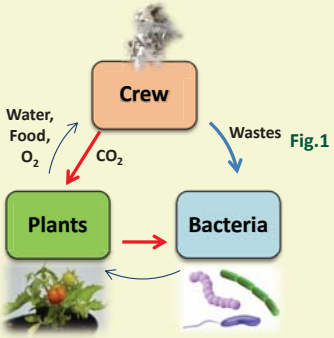


Fig.1

MATERIAL and METHODS

IRRADIATION PROCEDURE

Microtom dry seeds
Dose: 25 Gy of Calcium ions
Energy: 200 MeV/u;
LET: 180 KeV/µm

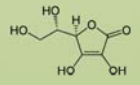
GROWTH and LEAF ANATOMY

Plant height
Flower number
Fruit number
Dry biomass
Leaf anatomy

PHOTOSYNTHESIS

- Chlorophyll and Carotenoid content
- Fluorescence a emission measurements
- D1 and Rubisco protein quantification

FRUIT ANTIOXIDANT CAPACITY



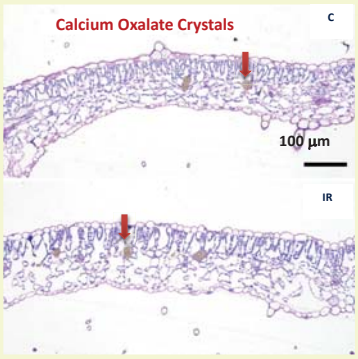
- Carotenoids, Anthocyanins, Polyphenols
- Ascorbic Acid

RESULTS

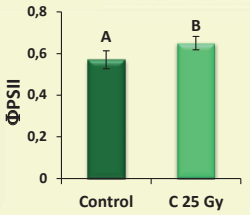
PLANT GROWTH and LEAF ANATOMY

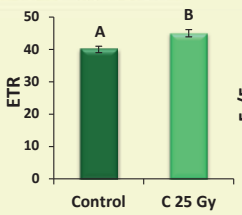
	Control		C 25 Gy	
Germination %	100	a	83.3	a
Flower Number	16.2 ±0.84	a	8.0 ±0.34	b
Fruit Number	23.0 ±1.00	a	11.0 ±0.52	b
Fruit diameter (cm)	0.16 ±0.001	a	0.24 ±0.001	b
Plant Height (cm)	7.90 ±0.001	a	6.14 ±0.001	b
Dry Biomass (g)	2.90 ±0.07	a	2.0 ±0.04	b

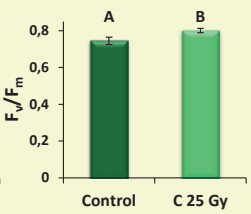
- Irradiation does not prevent plant germination
- Plants from irradiated seeds showed a reduced height and a more compact size
- Irradiated leaves do not show changes in leaf anatomy, but present a high number calcium oxalate crystals
- Irradiated plants produced a reduced number of berries with a large diameter



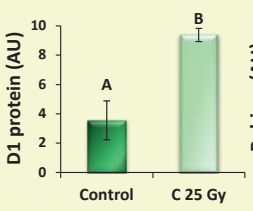
PHOTOSYNTHETIC EFFICIENCY

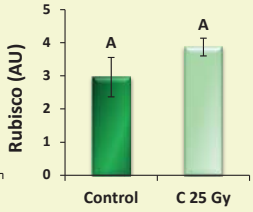


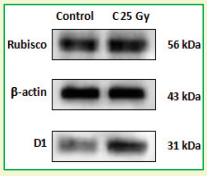




In irradiated plants, photochemical efficiency is promoted compared to control







Irradiated leaves showed higher levels of D1 protein and photosynthetic pigment content than control

ANTIOXIDANT RESPONSE IN FRUITS

	Control		C 25 Gy	
Ascorbic Acid Content (ng ml^{-1})	30.44 ± 0.68	a	38.98 ±1.27	b
Total Carotenoids (mg g^{-1} FW)	29.08 ± 4.87	a	59.73 ±7.96	b
Total Polyphenols (mg AGE g^{-1} FW)	0.159 ± 0.007	a	0.147 ±0.004	a
Anthocyanin content (µg g^{-1} FW)	132.28 ± 9.53	a	170.14 ±4.96	b

Plants from irradiated seeds produced fruits richer in ascorbic acid, carotenoids and anthocyanins

REFERENCES

[1] De Micco et al., 2011. Radiat. Environ. Biophys. 50:1-19
[2] Arena et al., 2014. Acta Astronaut. 104:419-431
[3] Arena et al., 2017. Biol Plantarum 61(2): 305-314

ACKNOWLEDGMENTS

The authors thank Prof Marco Durante (TIPFA, Trento, Italy; GSI, Darmstadt, Germany) for his support in irradiation procedure.

CONCLUSIONS

Plants germinated from irradiated seeds present a more compact size and a high photochemical efficiency compared to control. Moreover, irradiated plants produce bigger fruits richer in pigments and antioxidants (chlorophylls, carotenoids, anthocyanins and ascorbic acid) compared to control. It is noteworthy that irradiation of Microtom seeds with Calcium heavy ions at the dose of 25 Gy is perceived by plants as a stimulus to produce antioxidants as a safety mechanism. This response could represent an added value for Microtom increasing its suitability to be grown on board of space platforms.