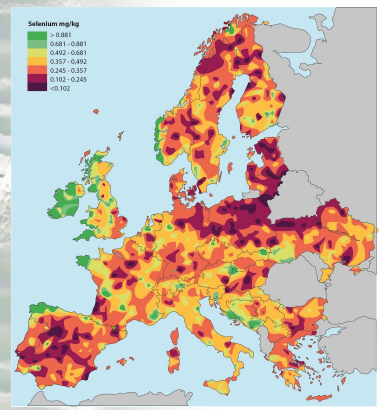
Consiglio Nazionale delle Ricerche

CNR IRET

CNR IRET Conference

Rome, February 18th-19th 2025

Selenium Nanoparticles: Improving Tomato Quality and Protecting Ecosystems



Background

- Selenium (Se) deficiency affects **one billion people**.
- Se uptake **depends on soil Se content**, with plant-based food being the main source.
- Italy and the EU have predominantly **Se-deficient** soils.
- Biofortification of fruit crops with Se is a strategy to enhance human dietary intake.
- Se intake **less than 50 µg/day** causes health problems. Se intake **above 400 µg/day** can be toxic.
- In plants, Se enhances antioxidant capacity, delays senescence, and slows fruit ripening.
- The poster summarise research from IRET on **sustainable Se biofortification** of tomato fruit.

Figure 1. Soil selenium content in Europe (Huag et. al., 2007)

Materials and Methods

Tomato cultivar	[Se] supplemented mg L^{-1}	Se chemical form	Se supplementation method	Se in enriched edible part (mg/kg DW)	% of Recommended Dietary Allowance provided by 100 g serving size	Reference
Red bunch	0 and 1	sodium selenate	added to nutrient solution	11.46	105	Pezzarossa et al [4]
Red bunch	0, 1 and 1.5	sodium selenate	added to nutrient solution	0.94 – 3.54	43	Puccinelli et al [3]
Micro tom	0, 5 and 10	chemical SeNPs	sprayed on plants	0.68	11	Shiriaev et al [2]
Micro tom	0, 5 and 10	sodium selenate	sprayed on plants	1.22	24	Shiriaev et al [2]

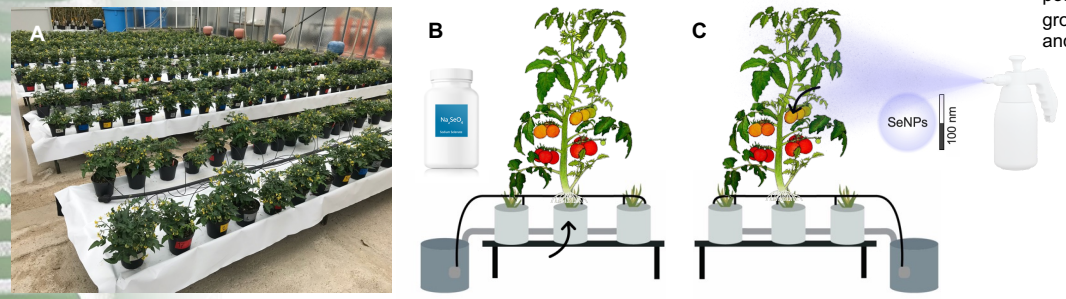


Figure 2. Experimental set-up (A), Se biofortification strategies scheme: foliar spraying (B) and substrate supplementation (C).

Results

Se accumulation [2]

- Se was accumulated primarily by vegetative parts (Fig. 3), over the time it has been transported to fruit.

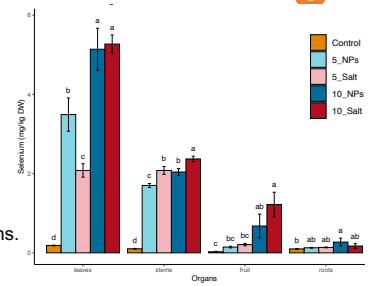


Figure 3. Se distribution in tomato organs.

CV Red bunch [3, 4]

- Se **postponed the ethylene climacteric peak** for 2 days (Fig. 4), reduced respiration rate and weight loss.
- Se delayed color change due to **postponed lycopene and b-carotene** synthesis and chlorophylls degradation.
- Se reduced color change rate and **ethylene rate** in red ripe fruit throughout the postharvest (Fig. 5).

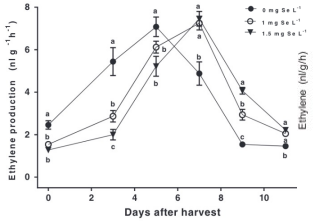


Figure 4. Ethylene production during post-harvest ripening in tomato fruit grown in nutrient solution with 0, 1 and 1.5 mg Se L^{-1}.

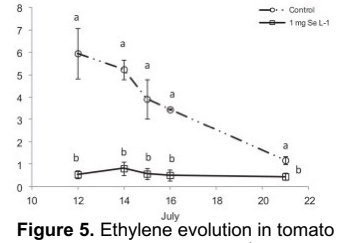


Figure 5. Ethylene evolution in tomato fruit treated with 1 mg Se L^{-1} detached at red stage and kept at 22 °C for 9 days.

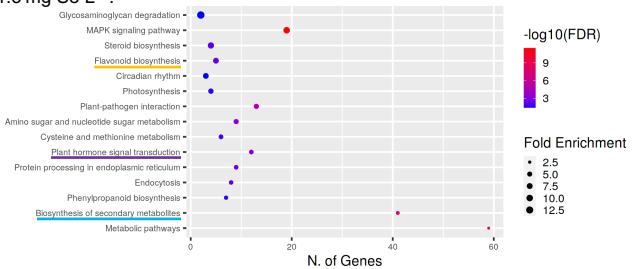


Figure 6. KEGG pathway enrichment analysis of DEGs in Se-enriched tomato fruit. Increasing the bubble size indicates an increasing enrichment score. Bubble colors from blue to red indicate an increasing false discovery rate (FDR).

CV Micro tom [2]

- RNA-seq showed that Se impacted expression of genes involved in **hormonal signaling**, **secondary metabolism**, **flavonoid biosynthesis**, glycosaminoglycan degradation (Fig. 6).
- Se **alternated biosynthesis** of **carotenoids and VOCs**, and **increased antioxidant polyphenols** (Fig. 7).

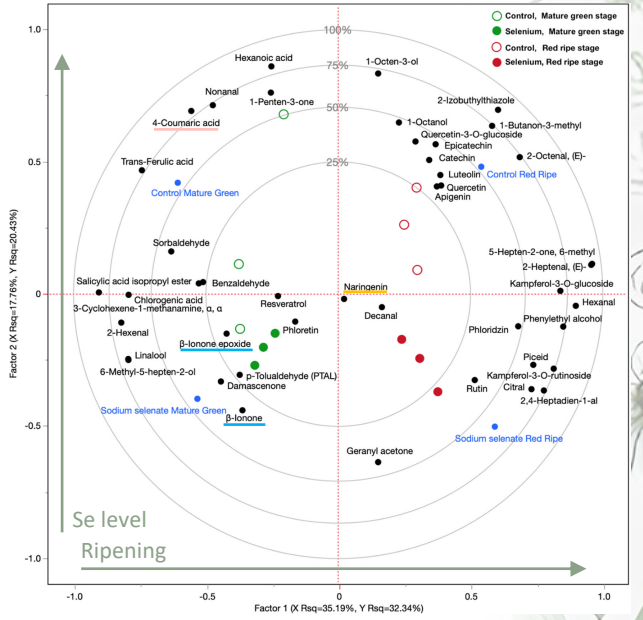


Figure 7. Partial least square discriminant analysis (PLS-DA). The model has been created using the identified VOCs and polyphenols as predictor variables, a factor combining ripening stage and Se concentration in tomato fruit as a response variable.

Conclusions

- Se biofortification allowed to **improve the nutritional value** of tomato.
- Application of NPs allowed to produce tomato fruit capable to safely fulfil or supplement RDA.
- Se **suppressed ethylene** biosynthesis or postponed appearance of the climacteric peak, positively **changed metabolome**, which indicate an improvement of the **shelf-life**, consumer-liking and **post-harvest** quality.

References

1. Haug A, Graham R, Christophersen O, Lyons. 2008. How to use the world's scarce selenium resources efficiently to increase the selenium concentration in food. Microb. Ecol. Health Dis. 19. 209-228.
2. Shiriaev A, Brizzolara S, Sorce C, Meoni G, Vergata C, Martinelli F, Maza E, Djari A, Pirrello J, Pezzarossa B, Malorgio F, Tonutti F. 2023. Selenium biofortification impacts tomato fruit metabolome and transcriptional profile at ripening. J. Agric. Food Chem. 71, 13554−13565.
3. Puccinelli M, Malorgio F, Terry LA, Tosetti R, Rosellini I, Pezzarossa B. 2019. Effect of selenium enrichment on metabolism of tomato (*Solanum lycopersicum*) fruit during post-harvest ripening. J. Sci. Food Agric. 99 (5): 2463–2472.
4. Pezzarossa B, Rosellini I, Borghesi E, Tonutti P, Malorgio F. 2014. Effects of Se-enrichment on yield, fruit composition and ripening of tomato (*Solanum lycopersicum*) plants grown in hydroponics. Sci. Hortic. 165, 106–110.

Dr. Anton Shiriaev, PhD

Co-Authors: Irene Rosellini, Beatrice Pezzarossa