

STUDY OF SILVER NANOPARTICLES UPTAKE BY *Helianthus annuus* CROP IN SALINITY CONDITIONS

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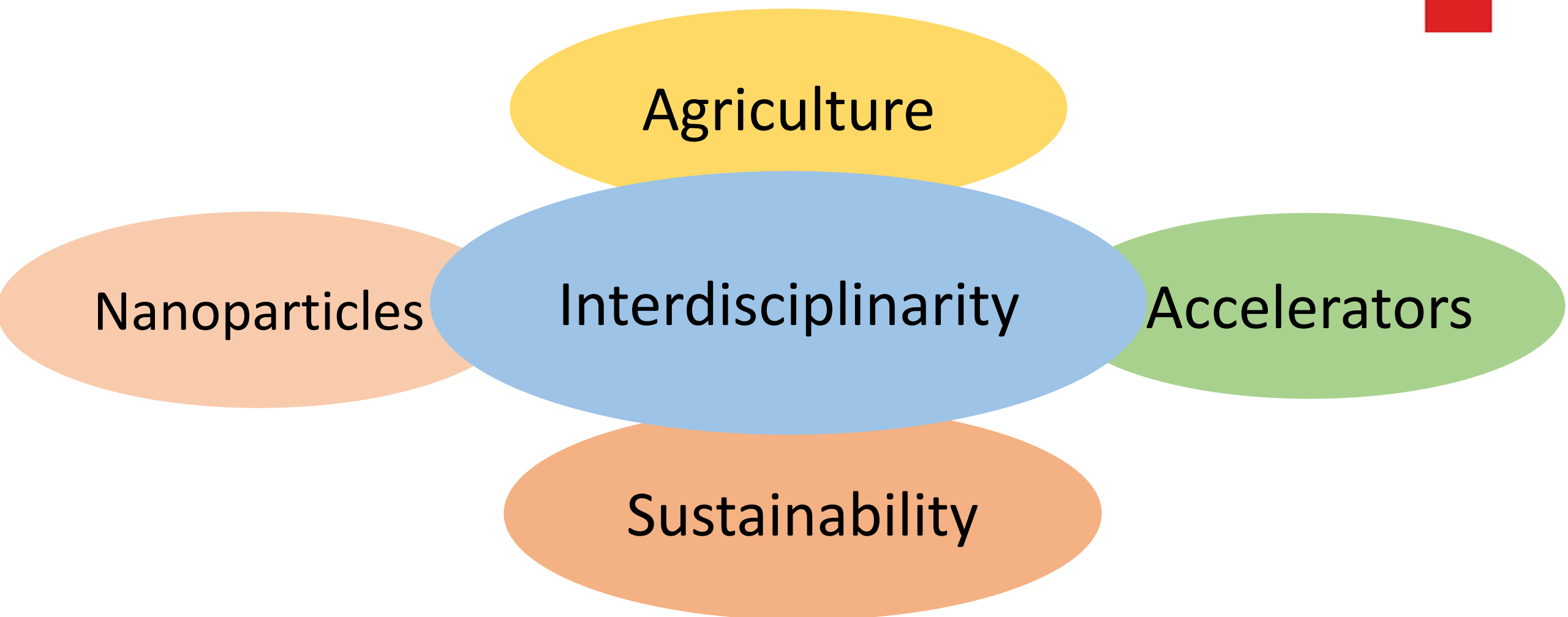
ACCELERATORS FOR RESEARCH AND SUSTAINABLE DEVELOPMENT

From good practices towards socioeconomic impact



23–27 May 2022

IAEA Headquarters, Vienna, Austria





- Food production: worldwide problem → agriculture and sustainable development



-30% of food loss



United
Nations

- How will be possible to feed 10 bilion of people in 2050?*

*<https://www.un.org/development/desa/dpad/publication/un-desa-policy-brief-102-population-food-security-nutrition-and-sustainable-development/>





Population increase



Agricultural production increase (1960s)

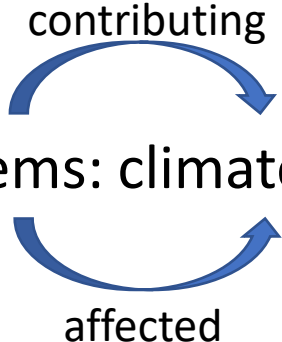


Food systems:

- Exceeding planetary boundaries for resources;
 - Producing food loss and waste.





- *Food (agrifood) systems: climate change, land degradation, biodiversity loss, pollution...
- 



Food and Agriculture
Organization of the
United Nations

“Sustainable food system: ensures food security and nutrition for all without to compromise economic, social and environmental aspects which could affect food security and nutrition for future generation.”

*<https://www.fao.org/food-systems/en/>





- How could we to contribute to solve such important problem?
- Is it possible to decrease those impacts caused by agrifood production systems and to guarantee nutrition and food and environment safety?





To improve the farming methods: drones,
mechanized and precision agriculture, different
cultures with technology use.



Nanotechnology





Nanoparticles and agriculture

Nanoparticles (NPs): materials at nano scale (size ≤ 100 nm)

Properties: antibacterial, antifungal, anti-inflammatory...

Farmacology (sun protector, make up, lotions, drug delivery, medicine...);
Industry (textil, toys, plastic, catalysts)

Agriculture: seed germination; fertilizer; controlled release of pesticides; increase the capacity of nutrient uptake by plants...





Where do the NPs go after their use
at industries and field???

interaction with
flora and fauna



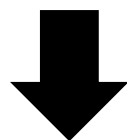
environment
dispersion





Unsolved questions:

- ✓ Accumulation of NPs in the environment;
- ✓ NPs uptake by plants and their dynamic in the plant tissues;
- ✓ Contribute to the food chain;
- ✓ Health or unhealth;
- ✓ Accumulation in the environment and live organisms: they still in NPs formulation or change to ionic species.



Properties and behavior of NPs depend on the size, shape, composition...





Our aim:

To study the uptake and internalization of AgNPs by crop plants.

✓ Sunflower (*Helianthus annuus*) exposed to AgNPs and NaCl;

✓ PIXE as the main analytical technique to investigate the internalization of Ag in the plant tissues.





Sunflower:

- ✓ Used as food and feed crop plant (animals and humans: seeds, oil, honey...);
- ✓ Hyperaccumulator of metals;
- ✓ Good for soil nutrition;
- ✓ Main producers: Ukraine, Russia, European Union, Argentina...





Salinity: problematic for arid regions



- ✓ Stress parameter of the soil. It's related to bad practices of cultivation (excess of fertilizer + poorly conducted irrigation systems);
- ✓ High concentration of salts → decrease of the nutrient absorption, causing limitation of crop growth especially in arid and semiarid regions of the world;
- ✓ It's not good for soil: decrease of water infiltration rates and increase the density.





Experiment



Post-doc fellow (2017-2018)

- *Biotechnical Faculty – University of Ljubljana*
- *Microanalytical Center – Josef Stefan Institute*

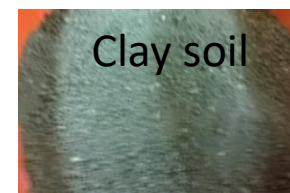
Hydroponic



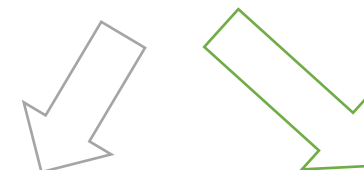
Soil

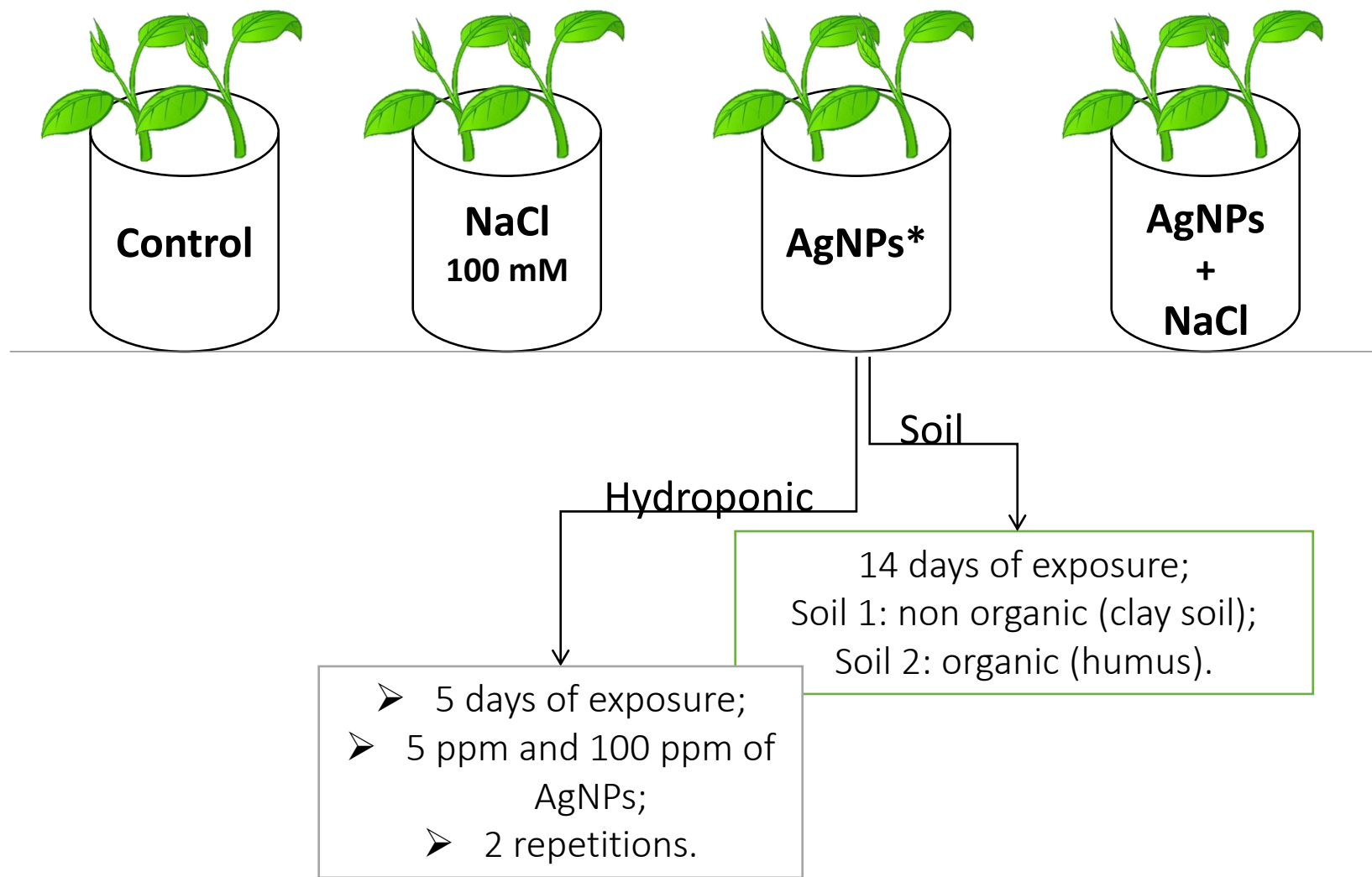


Clay soil



Humus soil





*AgNPs → Ag nanopowder ~ 90 nm (*Sigma Alderich*)



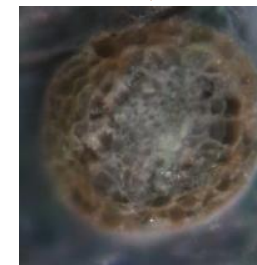
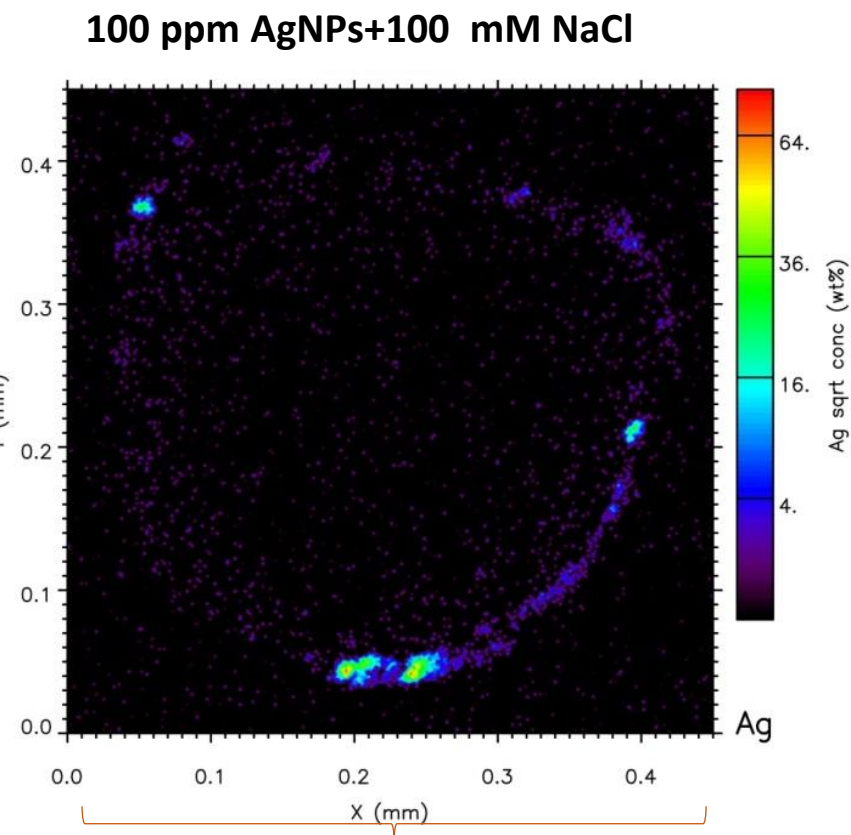
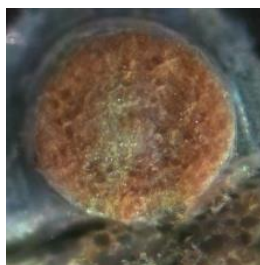
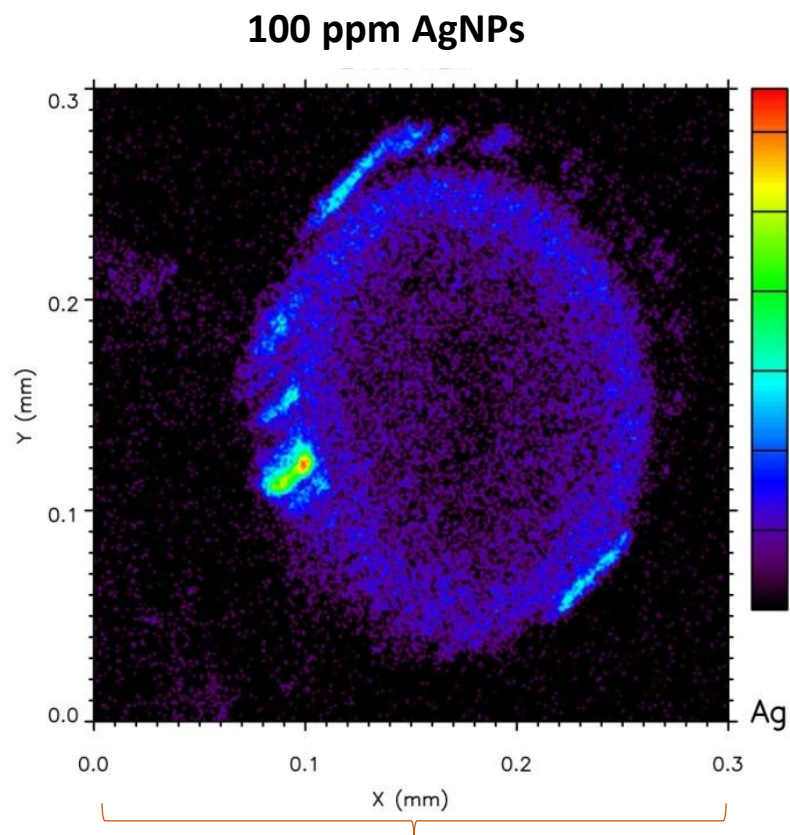


➤ Plants were harvested and samples were prepared for PIXE (60 μm thick, freeze dried), XRF (bulk samples), lipid peroxidation and pigments analysis (only for soil treatment).

- microPIXE measurements : MIC laboratory (Ljubljana, SL)
- 2 MV Tandetron;
 - 3 MeV proton beam;
 - SDD and Ge detectors;
 - GeoPIXE software to fit the PIXE spectra.

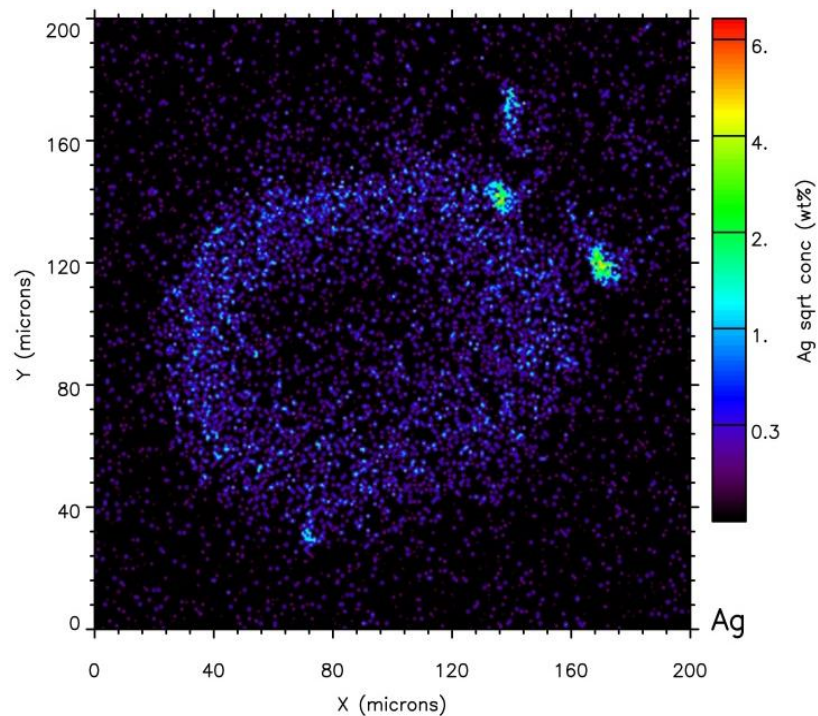


Results – Hydroponic Root

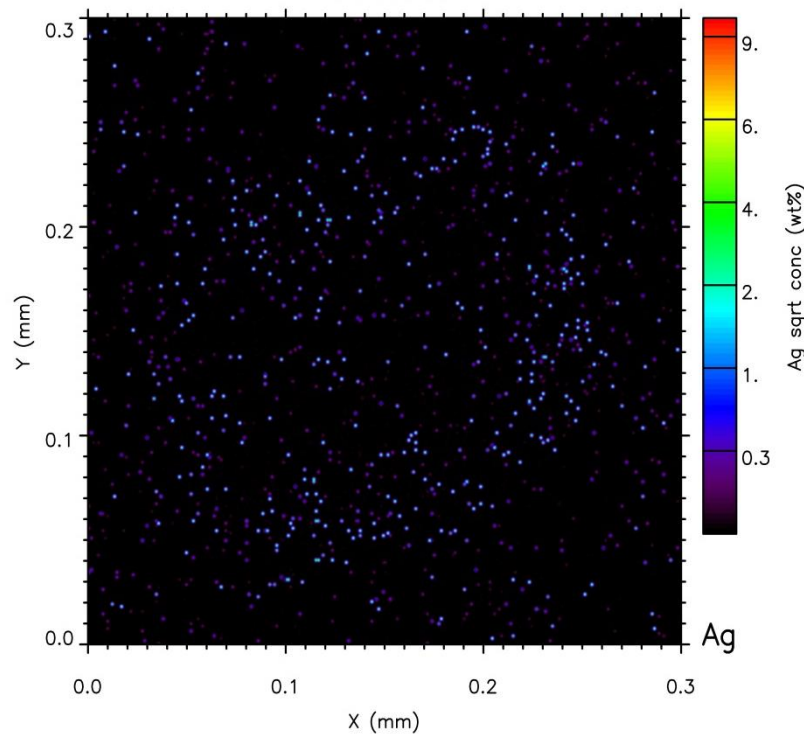




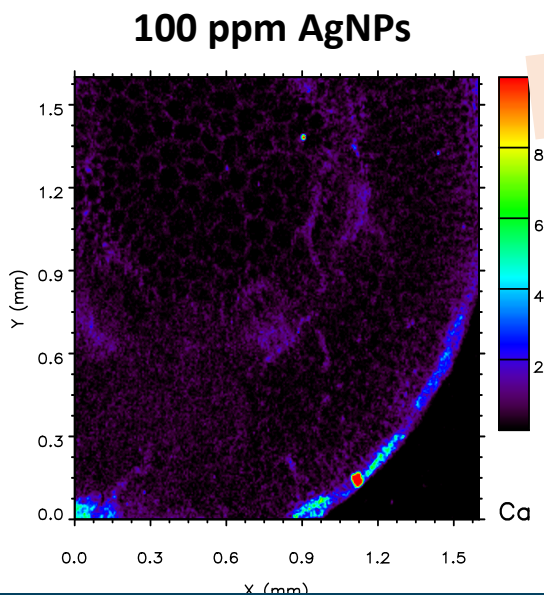
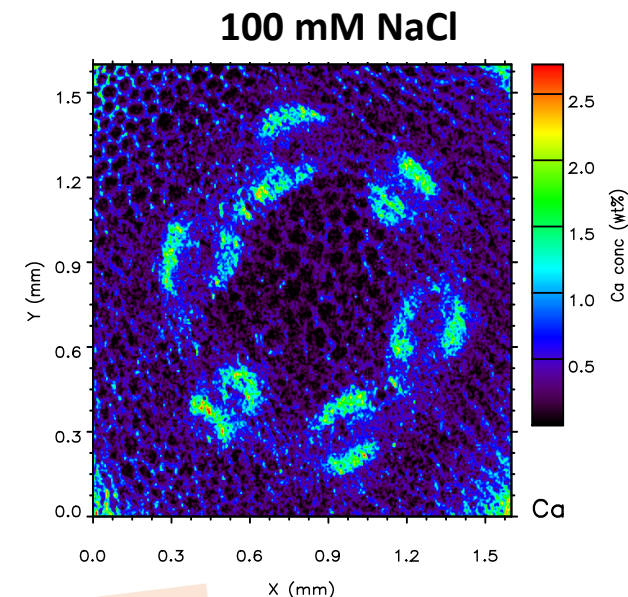
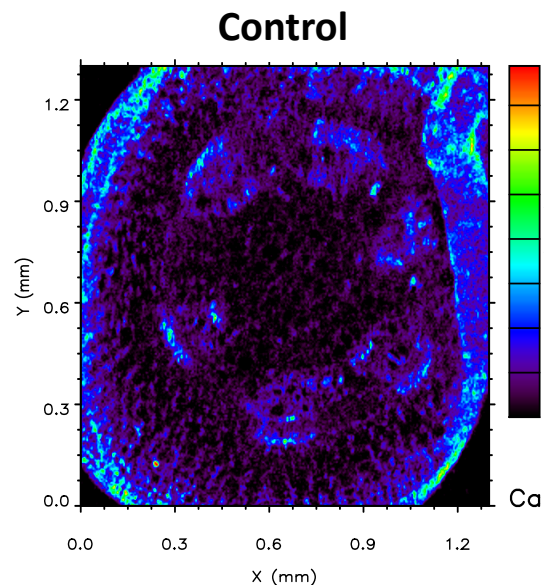
5 ppm AgNPs



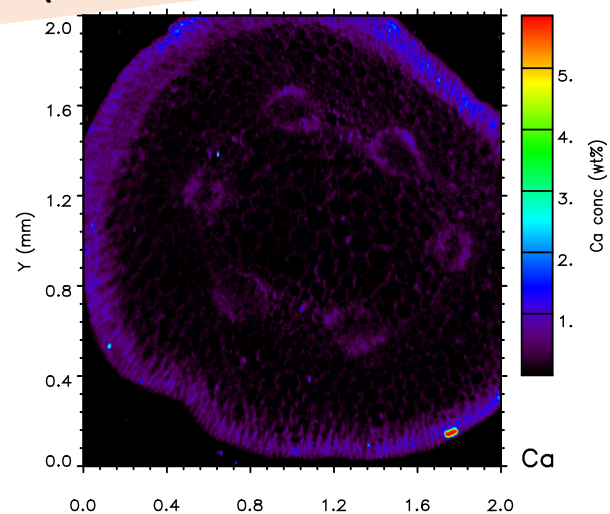
5 ppm AgNPs+ 100 nM NaCl



Results – Hydroponic Stem \rightarrow Ag < LOD



Reduction of Ca (-50%) AgNPs + 100 mM NaCl



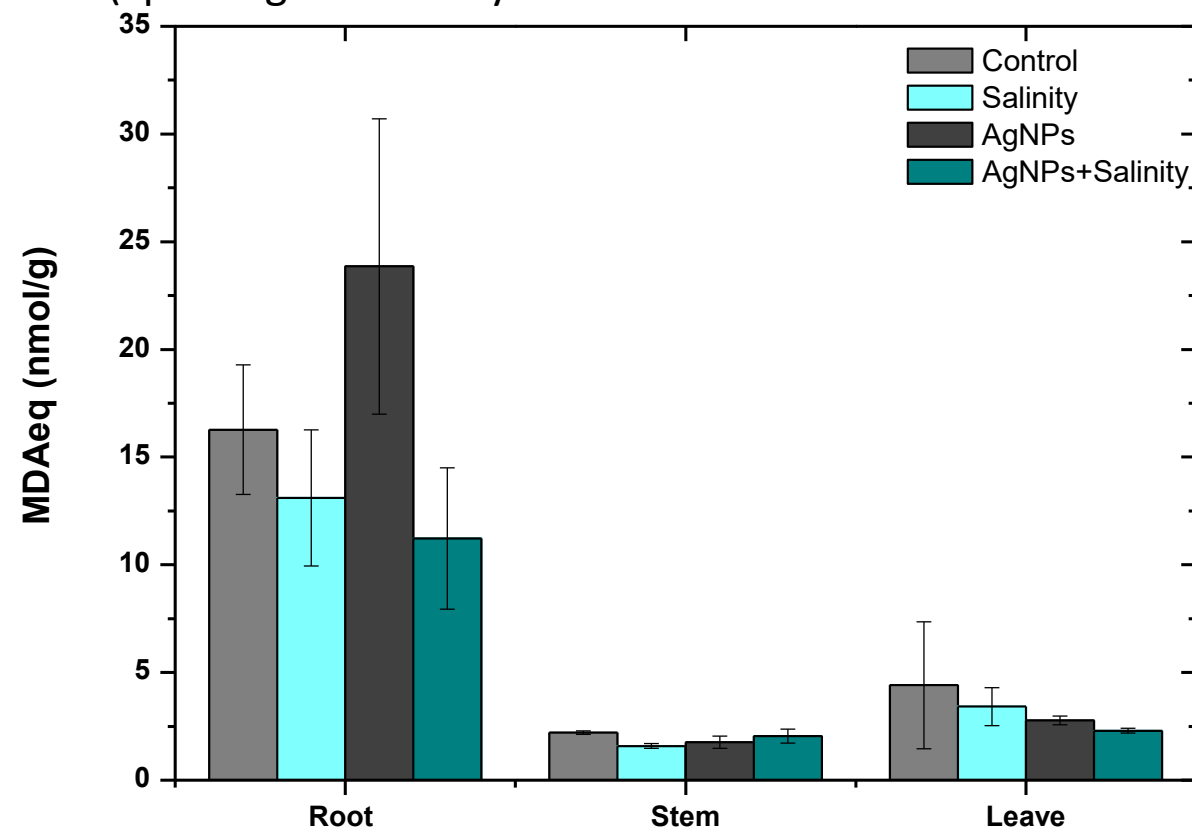


MicroPIXE: Ag concentration < LOD

Lipid peroxidation



(lipid degradation by free radicals under stress condition)

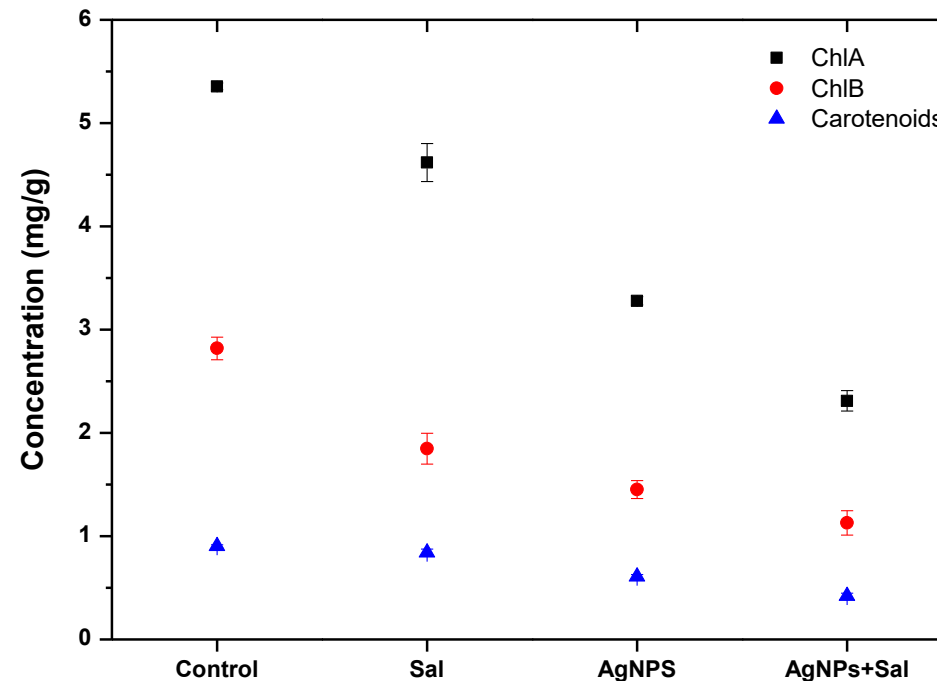
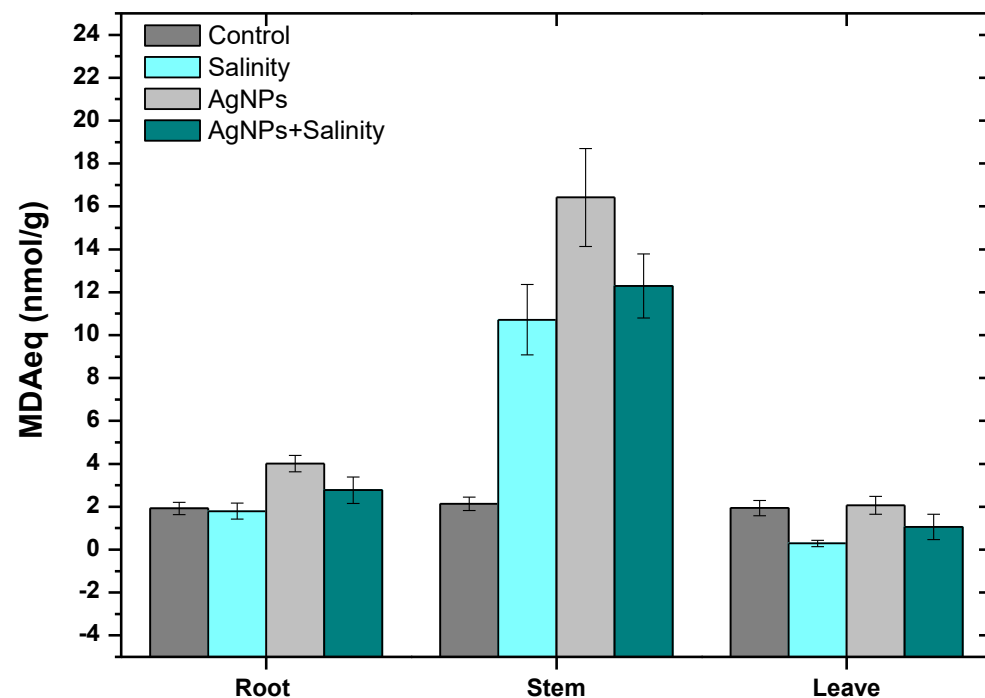




Soil 2



Results - Soil



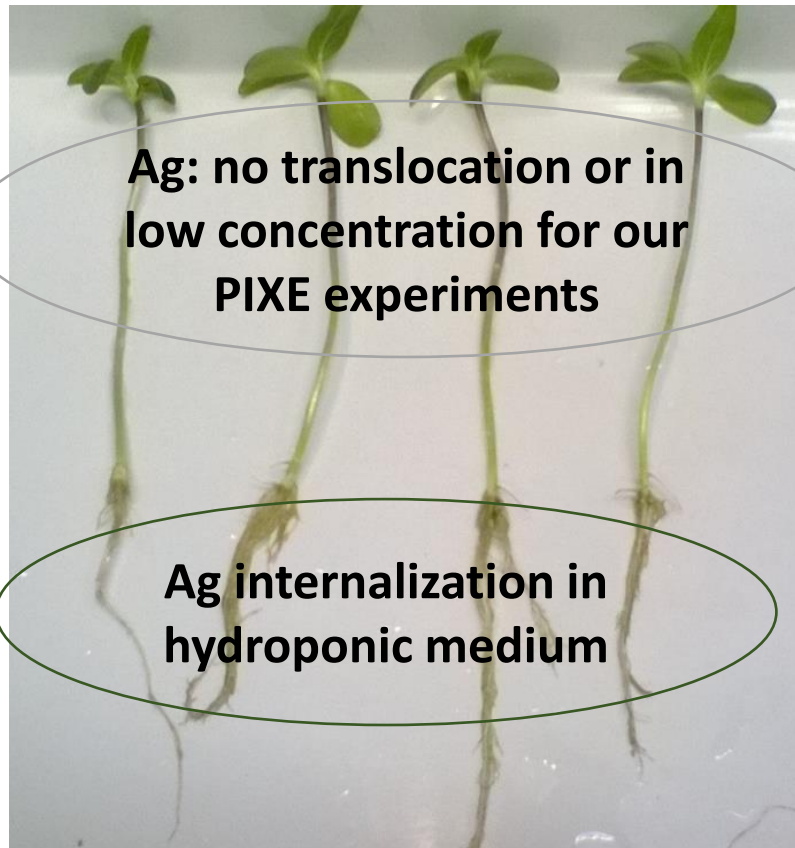
Reduction of carbohydrates production
by plant → plant can die



In summary:



Hydroponic



Soil:

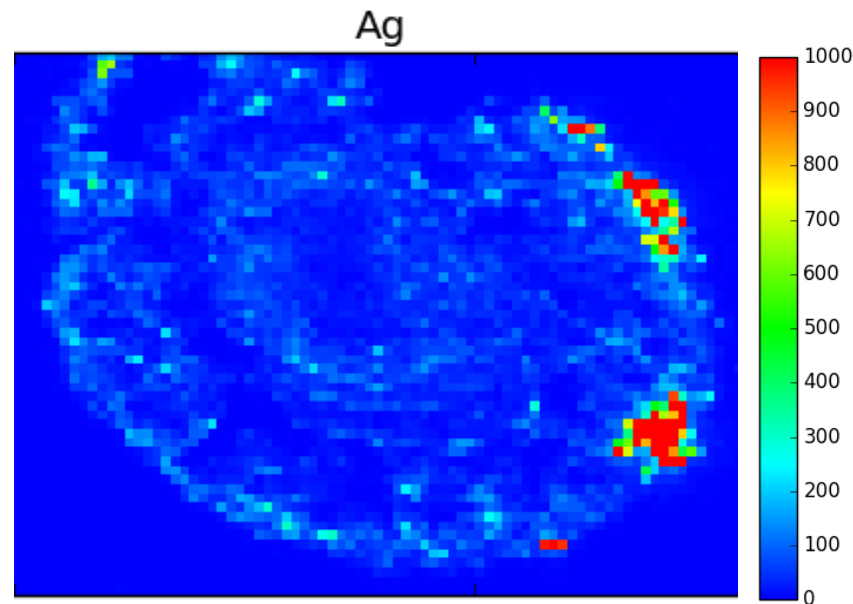
Plant stress depends on
soil type → biological
parameters



- Continue the experiment;
 - Other concentrations;
 - AuNPs?
 - Other plants and food chain;
- Seed germination expose to Ag and Au NPs.



Root treated with 100 ppm AgNPs
(XRF – ID21 Grenoble)



- XANES (Hamburg):
- Ag stil as NPs in roots;
- Flutuations in the spectra suggested orgnic ligands to Ag, such as S and O.





Accelerators for Research and Sustainable Development

- ✓ Important and unique applications to different problems;
- ✓ Complementary techniques and experiments (depends on the study);
- ✓ Clean sample preparation methodology (less environmental pollution);
- ✓ Analysis of different materials (inorganic and organic) using one analytical technique (food and agri production chain).



Thank you



Univerza v Ljubljani
Biotehniška fakulteta



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