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The proton beam influence on the sensitivity of wheat plantlets to AgNP pollution - preliminary results

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AIM OF THE STUDY

Due to its antibacterial features, silver is widely used in sanitation, cosmetics, pharmacy, wastewater treatment, etc. in the form of nanoparticles (AgNP). In Europe the estimated production of AgNP si sof about 0.6–55 tones/year. The fate of these nanoparticles is to reach finally the water, soil and air, polluting the biosphere.

As other study showed that proton beam exposure could change the young plantlet sensitivity to soil salinity, we searched for the influence of proton exposure of cereal seeds on the respective seedling sensitivity to AgNP pollution.

MATERIALS AND METHODS

The proton beam energy at thepoint of irradiation of thesampleswas 150 MeV, theaverage LET (Linear Energy Transfer) wasdE/dx = 0.539 keV/µm at the Bragg peak. Proton beam dosimetrywasbased on therecommendations of the International Atomic Energy Agency (IAEA). The irradiationwascarried out on dryseeds at the Dubna Institute for Nuclear Research. The irradiationdosewaschosen as 89 Gy.

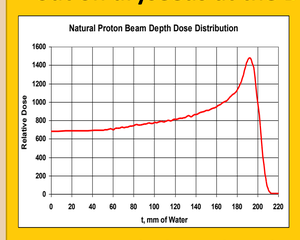


Fig 1. Depth dose distribution

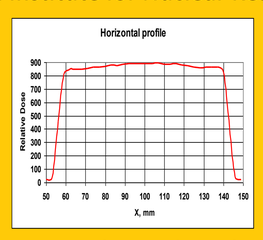
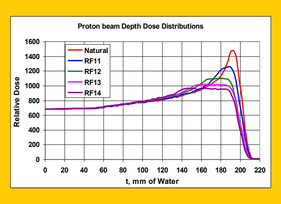
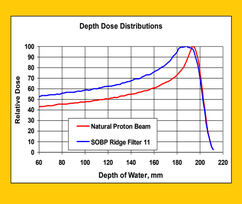


Fig 2. Relative dose, horizontal profile

Fig 3. Seed sample irradiation (seed bag exposed to horizontal proton beam)





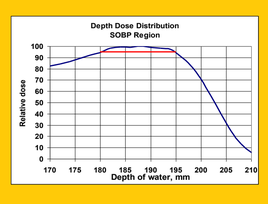


Fig 4. Set of Spread Out Bragg Peaks

Irradiation was carried out at the Spread out Bragg Peak (SOBP) proton beam. Dose rate at the SOBP was about 0.55 Gy/min.

After that the wheat seeds were arranged on paper filters embedded with distilled water, in Petri dishes and let to grow in controlled conditions in laboratory, 12 h light and 12 h darkness, at 24°±1°C.

The germinated seeds were supplied with appropriatevolumes of silver nanoparticle suspensions: native suspension and 10:100 diluted one for ten days.

The seedlings were grown in the same controlled conditions of lightning and temperature. The green tissue was biochemically analyzed to estimate the assimilatory pigment contents (chlorophylls and carotenes) according to literature procedure.

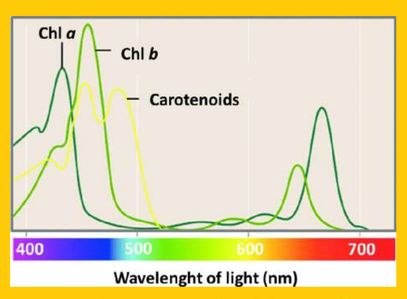


Fig 5. Lucia Guidi, Massimiliano Tattini, Marco Landi, In book: Chlorophyll; Intech, DOI: 10.5772/65594, 2017

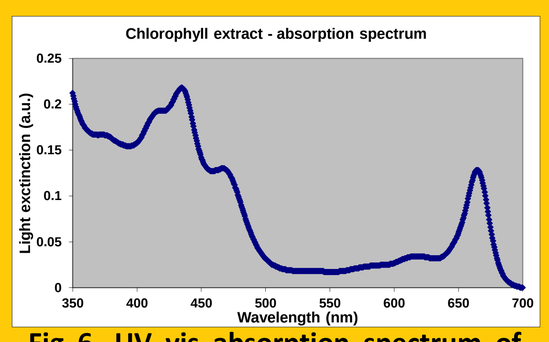
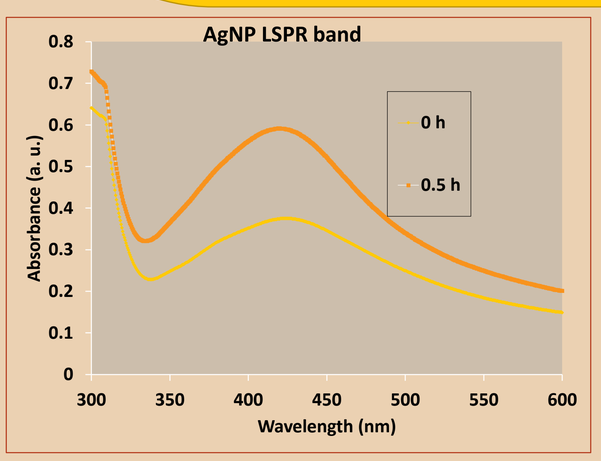


Fig 6. UV vis absorption spectrum of chlorophyll extract from wheat plantlets (control sample).



AgNP suspension was synthesized by reduction of silver nitrate with sodium citrate. The prepared suspension was exposed to UV-C lamp for 30 minutes to complete the reaction (emission power = 12 W emission in UV-C range, irradiance was of 0.88 W/m², in the center of the exposed sample ($W_{30\ min}$=558 J).

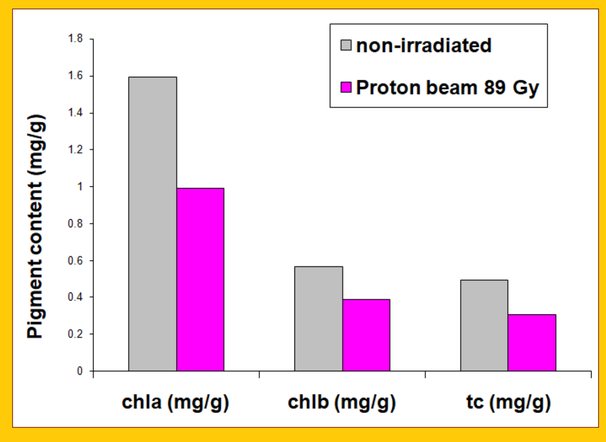
$$I = P\frac{2\alpha + \sin 2\alpha}{(2\pi^2 DL)}$$

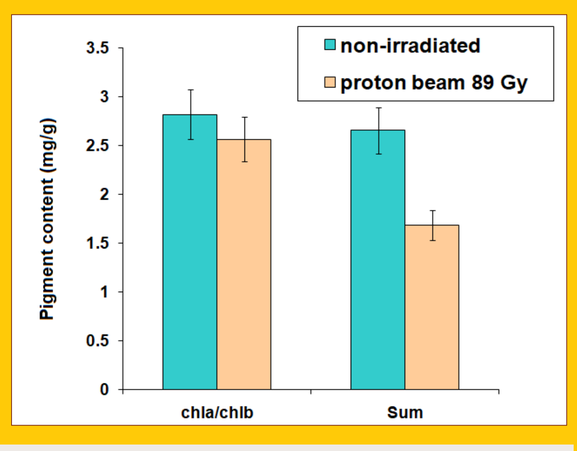
Fig 7. AgNP suspension absorption spectrum before and after UV C radiation exposure

During UV-C exposure, citrate-AgNPs suspension behaves as a dynamically colloidal system, leading to more nanoparticles formation derived from the initially unreacted silver and citrate ions . This leads to an increase in the LSPR band intensity.

RESULTS AND DISCUSSION

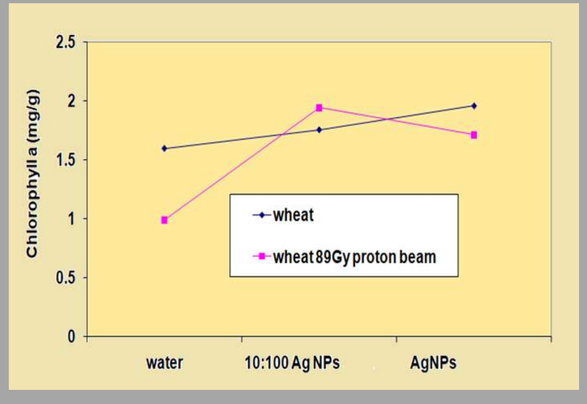
Fig 8. Photosynthetic pigments content (nonirradiated vs. proton beam exposed seeds)

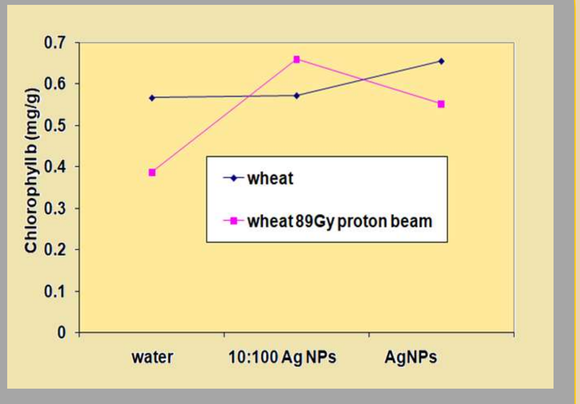


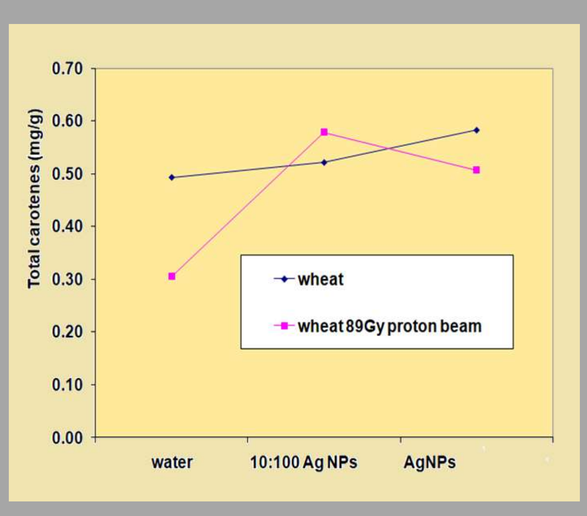


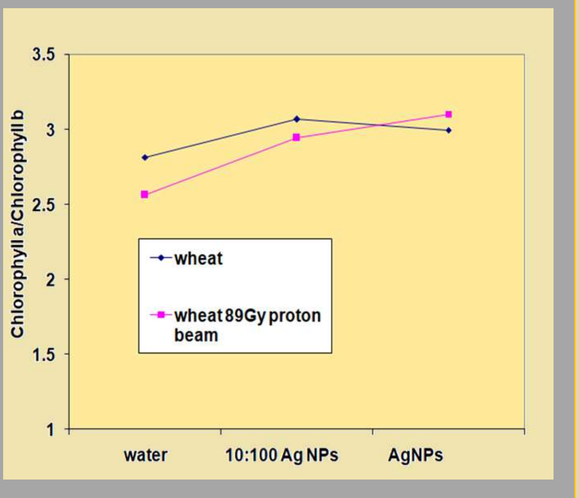
✓ Our results show that similarlly with other high energetic radiation effects, proton beam could injury DNA sequences controlling photosynthetic pigment synthesis, possiblly also chloroplasts organization pattern. Thus, chlorophyll and carotene synthesis could be diminished.

Fig 9. Photosynthetic pigments - content modifications in response to AgNP supply









✓In the lack of AgNP supply, the contents of chlorophyll *a*, chlorophyll *b* and total carotenes were diminished by proton irradiation with about 40%.

✓For diluted AgNP suspension, an increase of about 15% occurred while for undiluted AgNP suspension we have noticed a diminution of about 13% - in the samples treated with proton radiation.

✓Photosynthesis efficacy estimated by the ratio of Chlorophyll contents (chl *a*/ chl *b*) was enhanced in the samples exposed to proton beam, progressively up to about 20%. In the non-irradiated samples, this biochemical parameter varied insignificantly with slight tendency of increase in the samples supplied with diluted AgNP suspension.

CONCLUSIONS

✓ We highlight that for the experiments involving seed irradiation (proton irradiation and AgNP supply), we correlate the quantitative results with other studies from the literature pointing the influence of two complementary mechanism of action: harmful free radical generation under the radiation influence as well as surface microorganism annihilation that eventually protected the embryos, ensuring a better production of pigments after germination and growth .

✓ Further study will consider antioxidant enzyme assay in control and proton beam exposed samples.

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