COATED SILVER NANOPARTICLES AFFECT GERMINATION AND DISRUPT TOBACCO GROWTH

R. Biba[1], P. Cvjetko[1], M. Tkalec[2], D.M. Lyons[3], P. Peharec Štefanić[1] and B. Balen[1]

[1]Division of Molecular Biology, Department of Biology, Faculty of Science, University of Zagreb, Horvatovac 102a, HR-10000 Zagreb, Croatia (renata.biba@biol.pmf.hr, pcvjetko@biol.pmf.hr, ppeharec@biol.pmf.hr, bbalen@biol.pmf.hr)
[2]Division of Botany, Department of Biology, Faculty of Science, University of Zagreb, Rooseveltov trg 6, HR-10000 Zagreb, Croatia (mtkalec@biol.pmf.hr)
[3]Center for Marine Research, Ruđer Bošković Institute, G. Paliaga 5, HR-52210 Rovinj, Croatia (Daniel.Lyons@irb.hr)

INTRODUCTION

Silver nanoparticles (AgNPs) are being used in an ever increasing number of consumer products due to their excellent antibacterial and antifungal properties. Increased production will inevitably increase the potential for their release into the environment (Zhang et al. 2016.). Plants, as key components of biological systems, may serve as a potential pathway for AgNPs uptake, bioaccumulation and a route into the food chain (Rico et al. 2011). Studies on seed germination behaviour and seedling growth can help us to thoroughly understand the mechanism of AgNPs phytotoxicity. In this study we compared the effects of three differently coated AgNPs [citrate, polyvinylpyrrolidone (PVP) and cetyltrimethylammonium bromide (CTAB)] on germination and early growth of tobacco (*Nicotiana tabacum* L.). To examine whether the toxic effects of AgNPs originate from dissolved Ag^+ or nanoparticles themselves, cysteine, a strong silver ligand, has been applied.

MATERIALS AND METHODS

Size distribution of around 50 nm for all tested AgNPs was confirmed using dynamic light scattering (DLS, Malvern, UK) measurements. Zeta potential measurements suggested that AgNP-citrate and AgNP-PVP carry a negative surface charge (ζ = -39.9 ± 2.6 mV and ζ = -22.6 ± 5.3, respectively), whereas AgNP-CTAB appear to be positively charged (ζ = 41.7 ± 3.1). Tobacco (*Nicotiana tabacum* L.) seedlings were grown in a solid Murashige and Skoog (1962) medium supplemented with AgNP stock solutions to obtain 25, 50 and 100 µM concentrations, and combination of AgNPs and 125, 250 and 500 µM of cysteine. Germination rate was monitored for 5 days and 3 weeks old seedlings were used for weight and root length measurements.

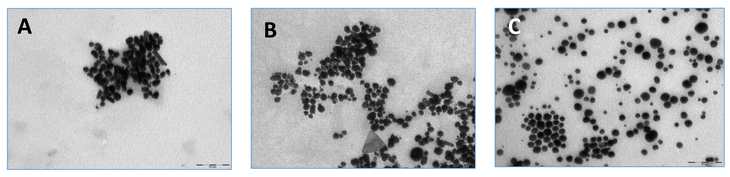

Figure 1. TEM images of AgNP-citrate (A), AgNP-PVP (B) and AgNP-CTAB (C).

RESULTS

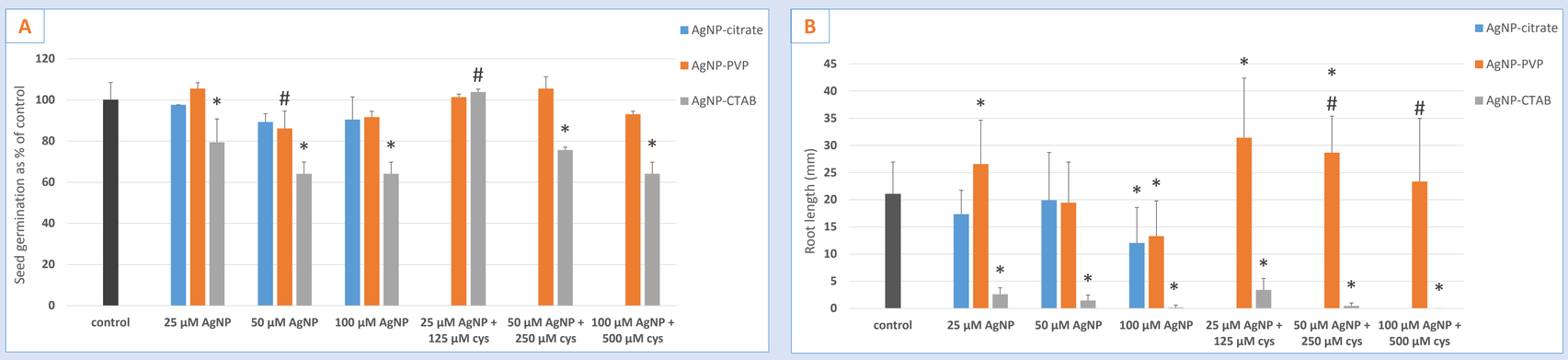

Figure 2. Germination percentage (A) and root length (B) of tobacco seedlings after treatment with AgNP-citrate, AgNP-PVP and AgNP-CTAB. Results are expressed as means of six replicates ± SE. Among each Ag-treatment asterisks denote significant difference from control and hash sign denotes significant differences among treatments with and without cysteine.

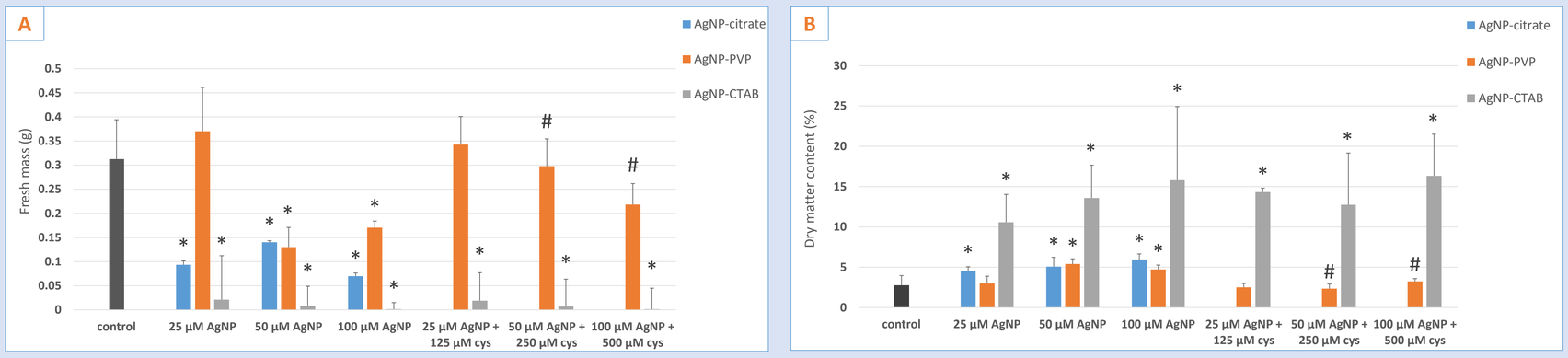

Figure 3. Fresh mass (A) and dry matter content (B) of tobacco seedlings after treatment with AgNP-citrate, AgNP-PVP and AgNP-CTAB. Results are expressed as means of six replicates ± SE. Among each Ag-treatment asterisks denote significant difference from control and hash sign denotes significant differences among treatments with and without cysteine.

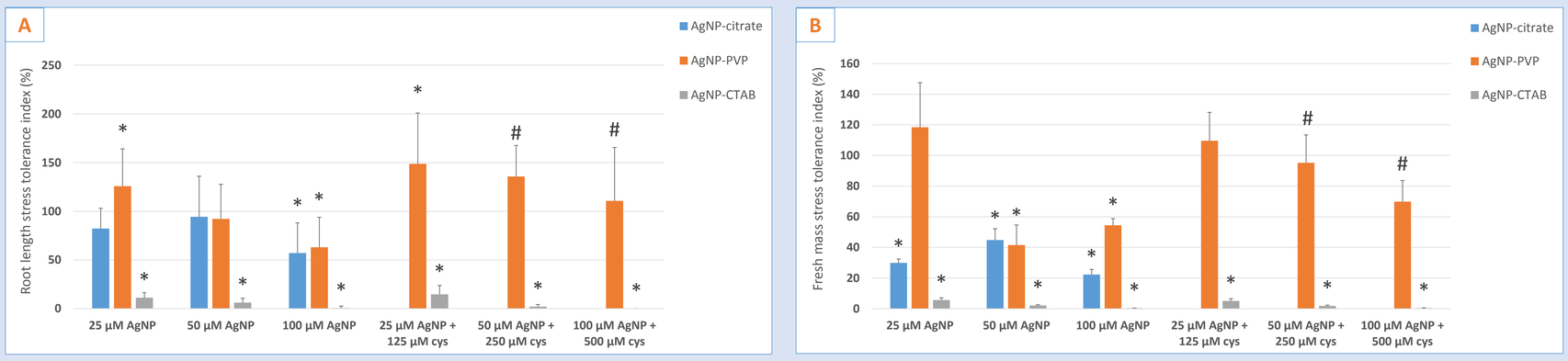

Figure 4. Stress tolerance index considering root length (A) and fresh mass (B) of tobacco seedlings after treatment with AgNP-citrate, AgNP-PVP and AgNP-CTAB. Results are expressed as means of six replicates ± SE. Among each Ag-treatment asterisks denote significant difference from control and hash sign denotes significant differences among treatments with and without cysteine.

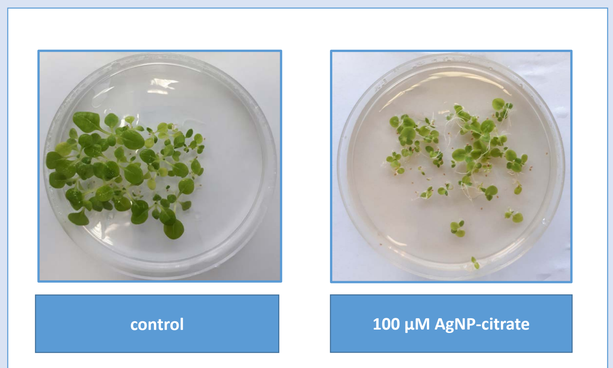

Figure 5. Three weeks old tobacco seedlings after treatment with 100 µM of AgNPs alone and in combination with 500 µM of cysteine.

CONCLUSION

AgNP-citrate did not cause any significant changes in germination percentage and root length of tobacco seedlings, while fresh and dry matter content showed only a slight reduction. Germination rate of seedlings exposed to AgNP-PVP and AgNP-CTAB was significantly reduced. Root elongation and seedling growth after these treatments were also negatively affected, resulting in reduction of fresh and dry mass and a decreased stress tolerance index. Cysteine significantly reduced harmful effects of AgNPs, especially AgNP-CTAB, thus showing that phytotoxicity of AgNPs at least partially derives from dissolved silver.

Literature:
Murashige and Skoog (1962), Physiol Plant 15:473-497
Rico et al. (2011), J Agric Food Chem 59:3485-3498
Zhang et al. (2016), Int J Mol Sci 17:1534

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