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IRON NANOFERTILIZERS FOR THE DEVELOPMENT OF SUSTAINABLE SOYBEAN CROPS

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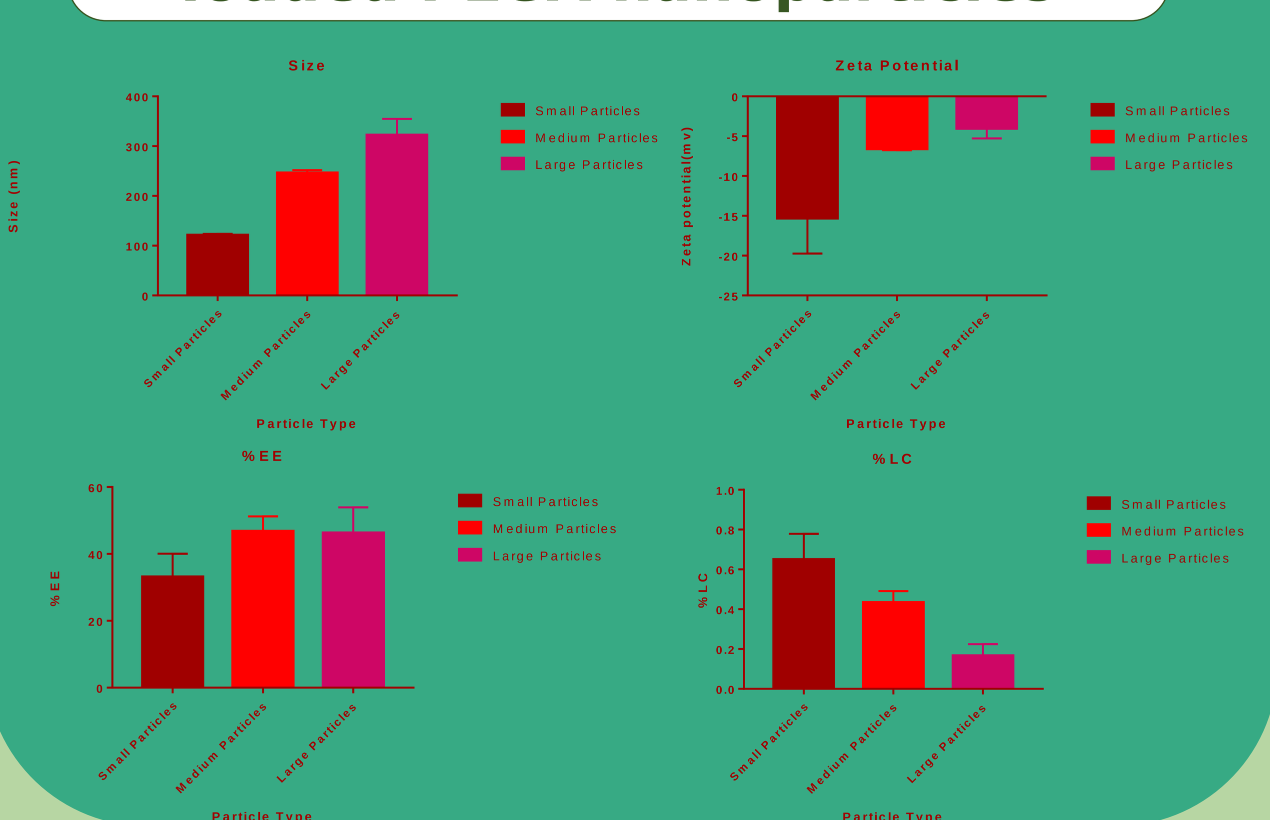
Introduction

Nowadays, about 30% of the world's arable land is composed of calcareous alkaline soils, which cause iron deficiency chlorosis in certain crops, having the potential to influence crop yields in a negative way [1]. The aim of this study is to create nanofertilizers, as nanoparticles carrying iron chelates, namely 3-hydroxy-4-pyridinones (3,4HPO) iron(III) chelates, which have shown to be effective in reducing chlorosis in *Glycine max* (soybean) plants in previous studies [1]. They can be used to treat affected plants, by providing a necessary supply of iron to chlorotic plants, and releasing it in a controlled and sustainable rate.

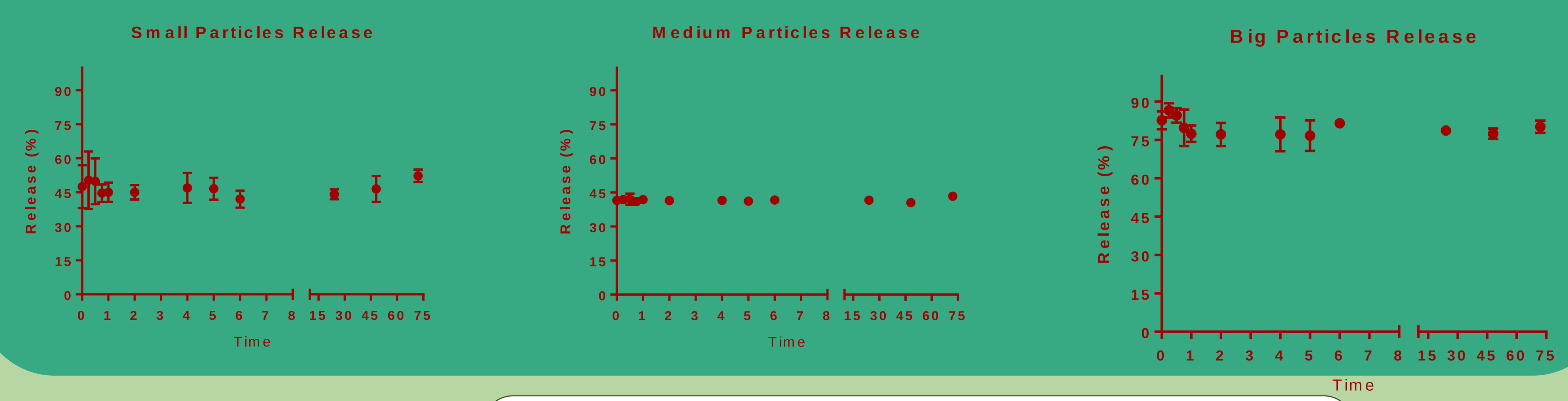
The initial part of this work consisted of the production, optimization and characterization of different formulations made of polymer-based nanoparticles, varying in size, and labeled with a fluorescent marker (rhodamine B). These formulations were tested in 2 weeks grown *Glycine max* plants to access the potential differences in their uptake, with the purpose of choosing the best formulation to carry out the future studies considering the iron-chelates loaded nanoparticles. Confocal fluorescent microscopy was used to investigate the absorption profile, revealing the potential of medium-sized nanoformulations, due to their notable presence in the roots, stem and leaves of the plant.

Methods & results

Production and characterization of different-sized rhodamine B loaded PLGA nanoparticles



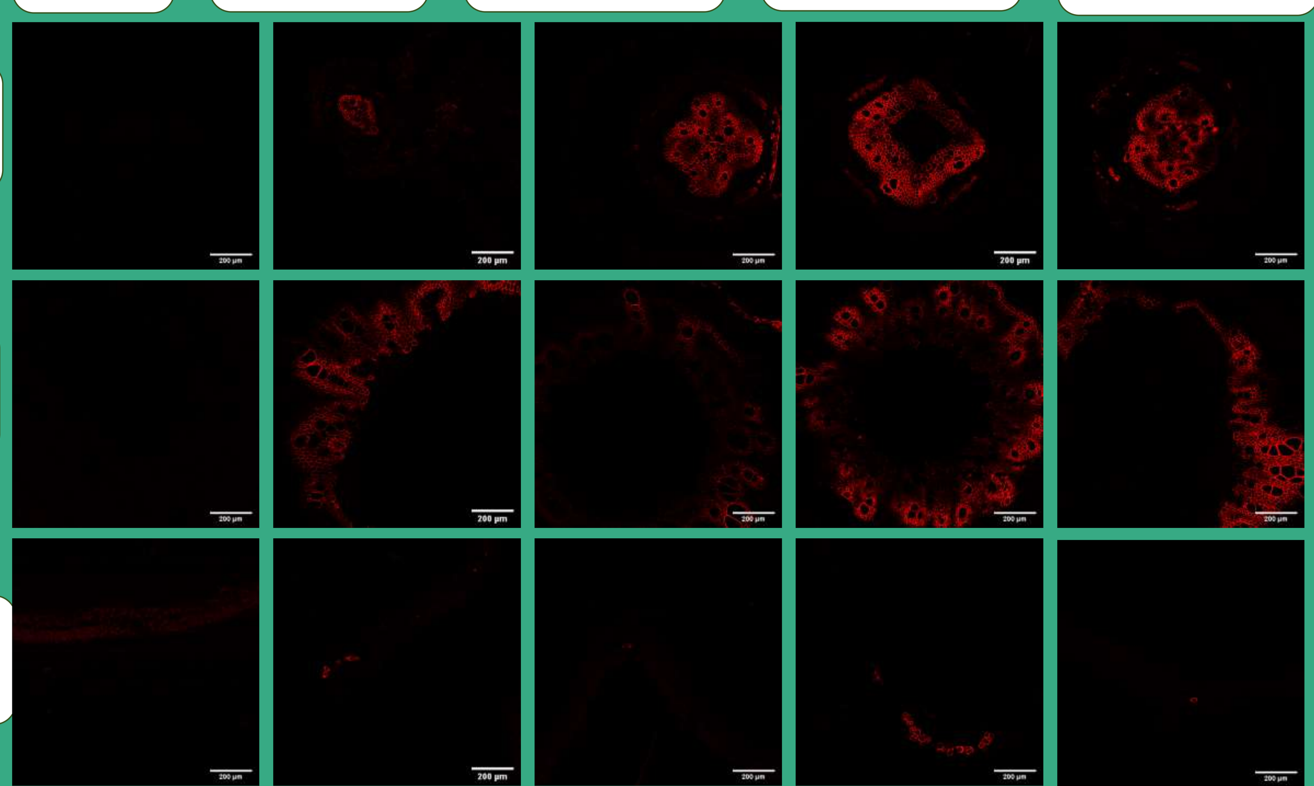
Rhodamine B release



Confocal fluorescence microscopy study of rhodamine B nanoparticles at λ=560/575 nm

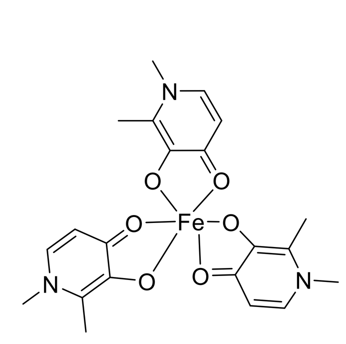
Control group | Rhodamine B solution | "Small" nanoparticles | "Medium" nanoparticles | "Large" nanoparticles

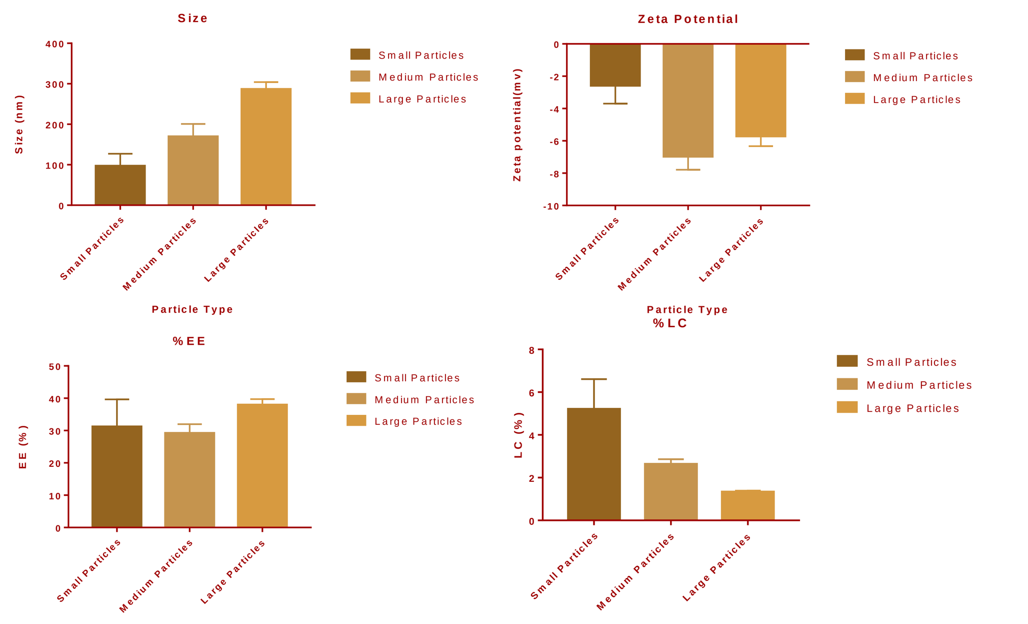
Roots
Stems
Leaves



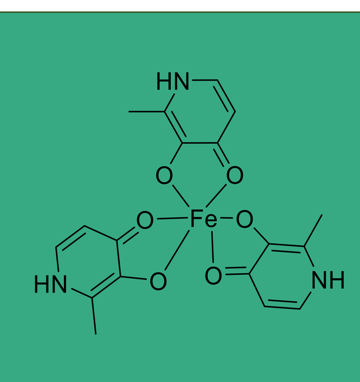
Production and characterization of different-sized iron chelate loaded PLGA nanoparticles

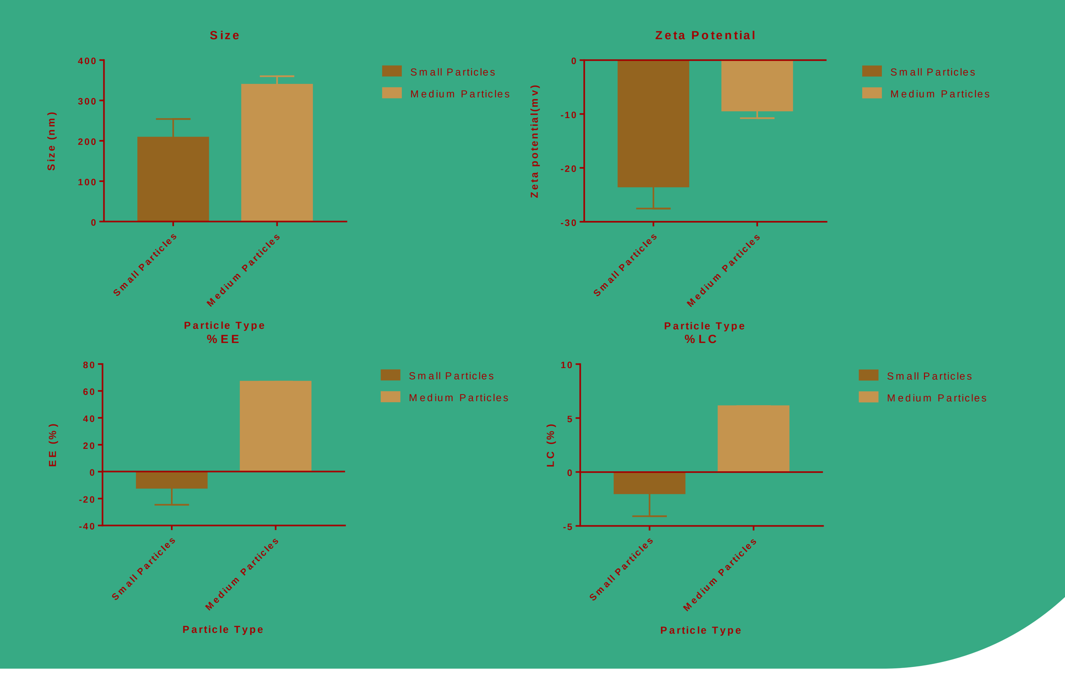
$Fe(dmpp)_3$ loaded nanoparticles





$Fe(mpp)_3$ loaded nanoparticles





Conclusions

DLS studies:

- <u>Rhodamine B NPs:</u> Small, Medium and Large NPs - sizes of 120, 246 nm and 322 nm; zeta potentials of -15, -6.5 and -4 mv, EE of 33, 47 and 46%; LC of 0.65, 0.43 and 0.16%, respectively.
- <u>FeDM NPs:</u> Small, Medium and Large NPs - sizes of 97, 170 and 287 nm; zeta potentials of -2.6 , -7 and -5.7 mv; EE of 31, 29 and 38%; and LC of 5.2, 2.6% and 1.3%, respectively.
- <u>FeMP NPs:</u> Small and Medium NPs - sizes of 207 and 338 nm; zeta potentials of -23 and -9,2 mV, EE of ~0% and 67%; LC of ~0% and 6%, respectively.

Confocal fluorescence microscopy analysis:

- In the roots and stems, rhodamine B seems to be well absorbed in aqueous solutions as well as in all the nanoformulations while in the leaves, smaller volumes of fluorophore seems to have been successfully delivered by RB aqueous solution and by some of the nanoformulations.

Final remarks:

- FeDM loaded particles are similar to the respective rhodamine B loaded NPs of the same name in most characteristics, while the FeMP loaded particles are more different, and the small ones have a lot of difficulty carrying this compound.
- Most of the proposed NPs show potential in delivering their iron chelates to the inside of *Glycine max* plants, and all the preliminary studies have been performed in order to finally analyze the effects of their application to plants grown in iron deficient mediums, in order to determine the most efficient type of particle to reduce or eliminate iron deficiency chlorosis in these plants.

Acknowledgements:
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References:

[1] Santos, C. S., Rodrigues, E., Ferreira, S., Moniz, T., Leite, A., Carvalho, S. M. P., Vasconcelos, M. W. and Rangel, M. (2021). Foliar application of 3-hydroxy-4-pyridinone Fe-chelate [Fe(mpp)3] induces responses at the root level amending iron deficiency chlorosis in soybean, Physiologia Plantarum, 1-11. Doi: 10.1111/ppl.13367