NANOTECHNOLOGIES: POSSIBLE SUPPORT FOR SUSTAINABLE AGRICULTURE?

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Abstract

Nanotechnologies can represent a valid tool to promote sustainable agricultural management, based both on the possibility of significantly reducing the quantities of some active ingredients used in the defense and fertilization of crops (control and saving of pesticides and fertilizers), and in treatments, using products alternative biocides and/or biostimulants of plant origin (essential oils, plant extracts), on a nanometric scale. An important application could be represented, for example, by the use of plant extracts on a nanometric scale, deriving from the self-production of medicinal plants for the defense of greenhouse and open field crops, thus optimizing the use of pesticides and fertilizers, reducing the presence of their residues on products and the pollution of water and soils. The use of nanotechnologies in agriculture would allow the development of precision agriculture, minimizing the impact on the environment and on the health of agricultural operators. However, some technical-scientific aspects of these techniques must be verified, such as the eco-sustainability and non-toxicity of the material constituting the nanoparticles, and a regulatory framework must also be defined to guarantee the safe use of nanotechnologies in agriculture for the protection of the environment and workers.

Introduction

Nanoparticles can be made up of inorganic, organic or hybrid materials, of small dimensions (at least one <100 nm). They have high surface/volume ratio and present absorption sites that can favor the targeted transport and a slow and sustained release of pesticides molecules, nutrients and water to the target sites, improving crop protection. Organic nanoparticles consist of lipids, synthetic or natural polymers (chitosan), dendrimers, and emulsions. Chitosan nanoparticles are used in agriculture to convey biopesticides for the treatment of seeds against fungal infections.

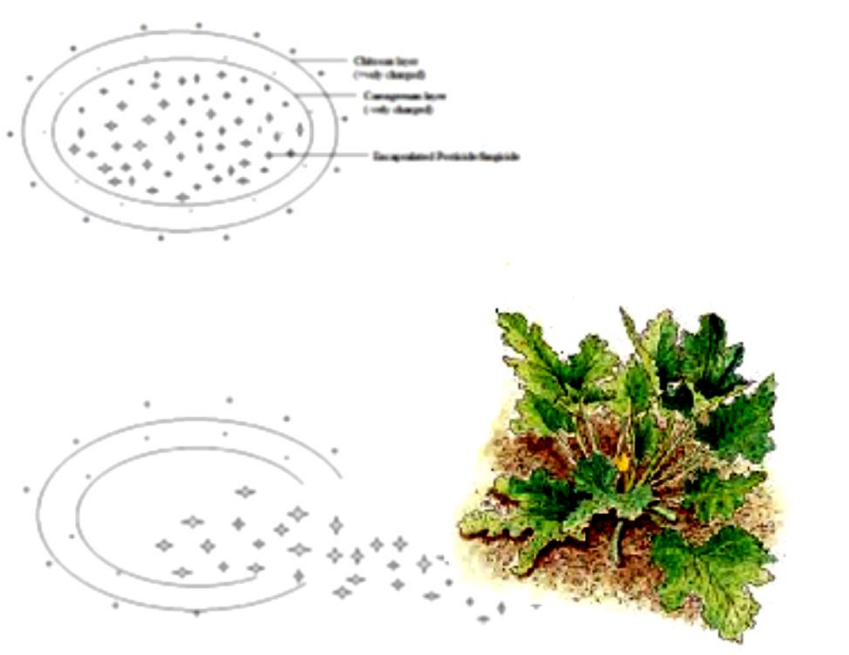


Figure 1. Controlled release of pesticides/fungicides/nutrients from nanocoating

Currently, the production of nanoparticles is oriented towards the use of plants and microorganisms (higher plants, algae, fungi, actinomycetes, bacteria and viruses) that provide biological materials, guaranteeing their ecological nature and simplicity in the production process.

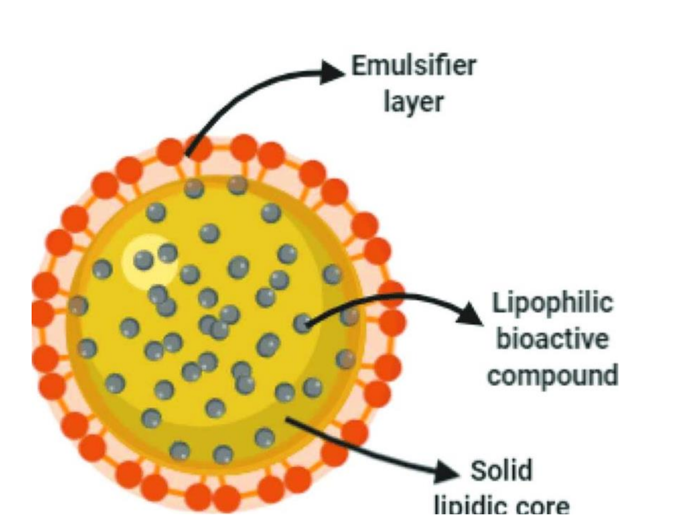


Figure 3. Schematic reproduction of a solid lipid nanoparticle (Vega-Vásquez et al., 2020)

How nanoparticles can be used in agriculture

The term precision agriculture has emerged in recent years, indicating the development of miniaturized systems for monitoring, evaluating, and controlling agricultural practices, including nanotechnology. Nanosensors and computerized controls, nanopesticides and nanofertilizers controlled release contribute significantly to precision agriculture as they can be used for targeted crop protection and improvement of their growth, yield and productivity. Nanomaterials can also be used to improve the nature of the soil and the stress tolerance of plants.

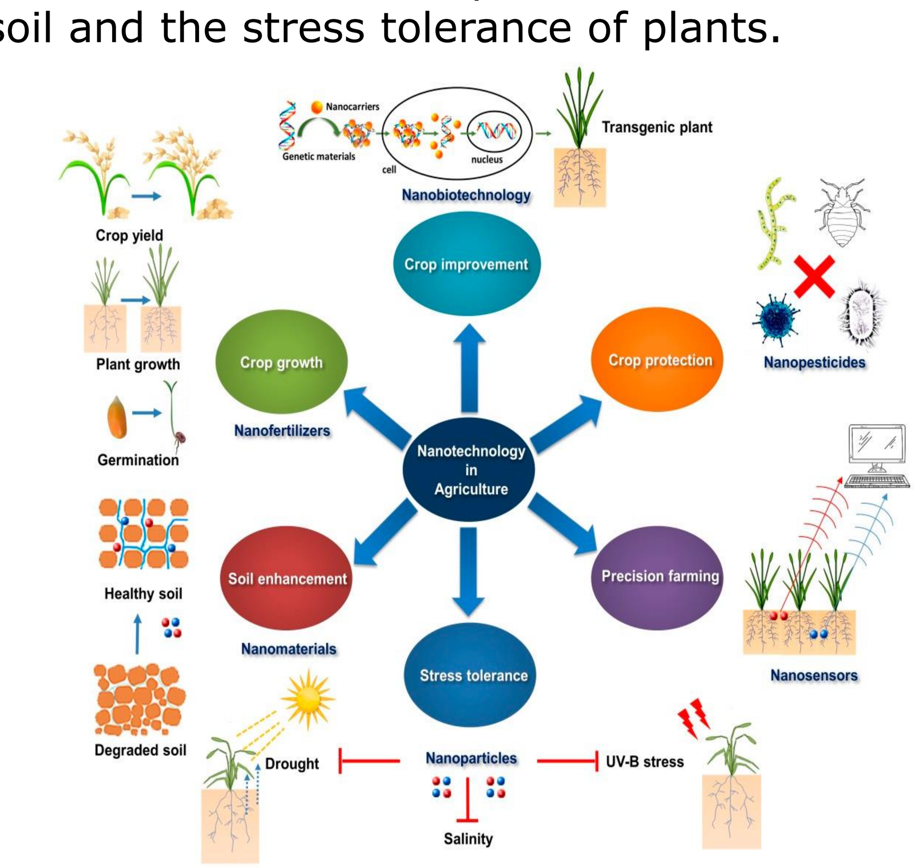
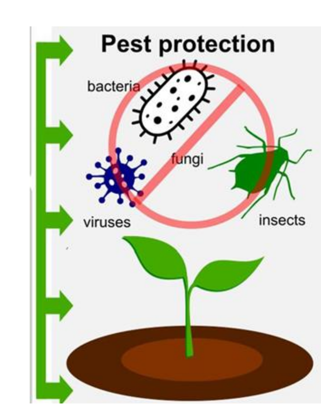


Figure 2. Applications of nanotechnology in agriculture (Modified and redrawn by Duhana et al, 2017).

Plant extracts and their use in agriculture

In recent years, interest has grown in the application of substances of natural origin in agriculture as an alternative to the use of pesticides. Plant extracts appear to be particularly effective in the control of pests and diseases of agricultural plants, although they do not show particular toxicity towards spontaneous flora and fauna, beneficial insects and microbiota. The plant extracts, being a combination of compounds, have a greater activity than the single active ingredient, such as to determine a more effective response (synergism). Natural extracts have been shown to be effective in protecting crops from pests and stimulating crop growth and productivity, reducing soil and water pollution and the risk of exposure to chemicals for workers.



Nanoparticles and plant extracts: their possible use in sustainable agriculture

A possible application of nanotechnologies to sustainable agriculture could be represented by the creation of products based on aqueous plant extracts using nanoparticles as a vehicle for administration to crops, as part of a planned study aimed at verifying the possibility of finding simple and low cost, to self-produce aqueous extracts of aromatic plants on the farm and thus reducing the chemical risk for the environment and for agricultural operators.

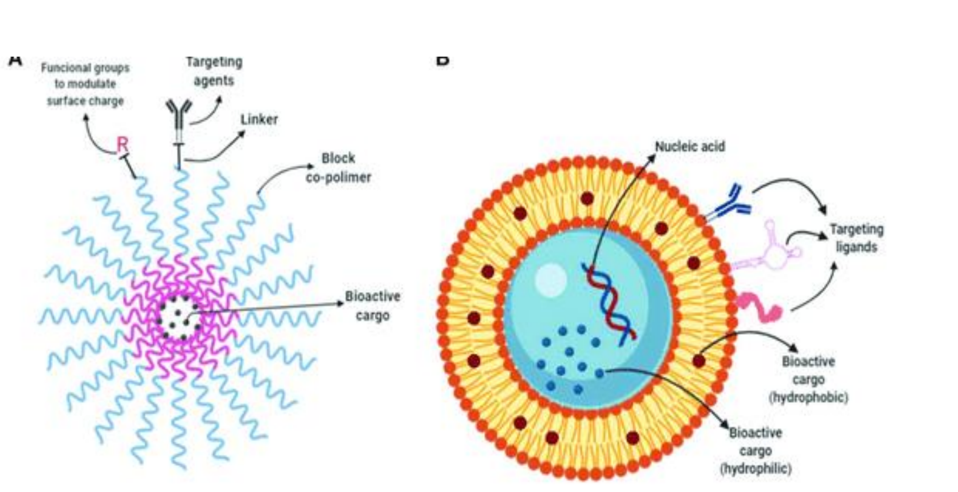


Figure 4. Schematic representation of polymer micelles and liposomes (Vega-Vásquez et al., 2020)

Conclusions

The use of nanotechnologies in agriculture could allow the development of precision agriculture while respecting sustainability. The use of natural substances for the development of pesticides in nanoparticles represents an effective and eco-sustainable alternative for the management of plant diseases, allowing a more efficient assembly of active ingredients organic products and their controlled release over time, respecting the environment, limiting the use of chemicals and economic losses. However, some technical-scientific aspects of these techniques should be verified, such as eco-sustainability and the non-toxicity of the material constituting the nanoparticles. It would also be necessary to define a regulatory framework defining the safe use of nanotechnologies in agriculture for the protection of the environment and workers.

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