

Nanotechnologies: Novel Solutions for Sustainable Agriculture

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Nanotechnologies

Development of nanotechnologies has taken a significant extent since the 1970s. These technologies concern all processes and manipulations of materials with at least one dimension that approximately measures 1–100 nm. Nanomaterials and applications derived from using nanotechnologies are of interest to agriculture. They present opportunities to help address the issues of sustainable agriculture by reducing agricultural inputs and improving productivity and food and water safety [1]. Currently, nanotechnologies have many applications in all stages of production, processing, storing, packaging and transport of agricultural products.

One application of nanotechnologies in agriculture addresses low use efficiency of inputs. Nano sensors are devices that respond to environmental conditions converting them to a useful form of information. They are capable of detecting very small amounts of contaminants, pests, nutrients and even stress caused by nutrient deficiencies, drought, and temperature or pathogen presence. This detection engages nano delivery systems that deliver, with high precision, drugs or nutrients to crops and animals [2]. Networks of nano sensors positioned throughout cultivated fields guarantee real time monitoring of the crop growth and provide essential data leading to better agronomic practices. Hence, controlled release mechanisms via nanoscale carriers avoid temporal overdose, reduce the amount of agricultural chemicals used and minimize input and waste [3,4]. The mechanisms involved in efficient delivery, storage and release include encapsulation and entrapment, polymers and dendrimers and others [5].

Agriculture requires considerable amount of fresh water, and contributes substantially to its pollution through the use of pesticides, fertilizers and other agricultural chemicals. Nanoporous materials are capable of storing water and slowly releasing it, depending on drought's level controlled by wireless nano sensors, allowing less water use and decreasing losses into the environment.

Smart nano-sensors can therefore help maintaining farms with precise control and report timely needs of crops and animals [6].

Soil quality is one of the most important factors controlling crop yields. Nano zeolites are crystalline aluminum silicates that allow the exchange of ions and reversible dehydration [1]. They can improve the water retention of sandy soils and improve porosity in clay soils.

Pesticides and fertilizers encapsulated in nanoparticles are also being developed. Studies estimated that using nano pesticides could significantly reduce the amounts applied by 70 or 80 percent in quantity, cost and impact on the environment [5]. Bactericidal coatings

are an example of nano pesticides used in poultry houses [7]. It incorporates nano titanium dioxide with photocatalytic properties activating it when the coating is exposed to natural or ultraviolet light. Nano fertilizers increase the efficiency and the uptake by the plant and may also protect soil quality by decreasing toxic effects associated with over application. Nano vaccines with improved delivery routes are industrialized in aquaculture.

In the coming years, more research on the application of nanomaterials in agriculture is expected but these materials are still very criticized due to the lack of studies associated with environmental security and food safety [8]. In fact, the future use of nanomaterials has recently raised concerns regarding their disposal and many international programs are nowadays studying the risk related to their use.

Nanotechnologies are promising technologies with the ability to create massive changes in food and agricultural systems. Even though the risk assessment of the use of nanoparticles in agriculture is still not well defined, nanotechnology-aided applications can increase production and allow better management and conservation of inputs. These applications will assure optimal planting and harvesting moments and optimal water, fertilizers and pesticides applications.

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