Current possibilities in Agricultural Nanotechnology

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Abstract: The European Commission has designated nanotechnology with high regard to contributing to long-term competitiveness and development in a variety of industries. The contemporary issues of sustainability, food security, and climate change have prompted academics to look towards nanotechnology as a new source of crucial agricultural advancements. Concrete contributions, on the other hand, are yet unknown. Agricultural applications have failed to reach the market, in spite of the various prospective benefits of nanotechnology and the expanding trends in intellectual property publications. The lack of commercial applications might be due to a number of issues. Industry analysts say that agricultural nanotechnology falls short to deliver a significant financial return to pay the massive initial investment expenses. New EU nanotech laws, on the other hand, may induce regulatory uncertainty for already-on-the-market goods and have an influence on public perception. Recent studies, on the other hand, demonstrate that masses are not reluctant towards nanotechnology, and that the introduction of nanotech goods with obvious advantages would almost certainly increase customer acceptance of more sensitive use. The rapid progress of nanotechnology in other key industries may someday be employed for agricultural applications, simplifying their expansion.

Key Words: —*Nanotechnology, agriculture, fertilization, nanomaterials.*

I. Introduction

The field of nanotechnology is still in its infancy. However, progress is being made in the study and development of possible beneficial qualities of nanomaterials, which might help to find new and altering applications for mineral commodities (Buckingham, 2007). Nanoscale particles' novel chemical and/or physical characteristics give important functionalities that are being quickly explored in the fields of health, biology, electronics, material science, and energy, among others(Khan et al., 2019). These encouraging trends also apply to the agriculture sector, where constant innovation is critical in light of rising global food security and climate change issues (Akter et al., 2022). Agriculture has already benefited from technical advances such as synthetic chemicals, hybrid varieties, and biotechnology, and researchers are now exploring for a novel source of agricultural advantages in nanotechnology.

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While nanotechnology has the potential to enhance the food industry (particularly food processing, packaging, distribution, and functional food), its exact influence on agriculture is uncertain (Sekhon, 2010).

According to prominent R&D evaluations, agricultural nanotechnology research has been continuing for more than a decade, with the goal of finding answers to a variety of agricultural and environmental concerns, including sustainability, enhanced varieties, and greater production(Prasad *et al.*, 2017). Many writers have reported an increasing trend of scientific publications and patents in agricultural nanotechnology, particularly for disease control and crop protection (Parisi *et al.*, 2015). Nanomaterials in agriculture attempt to minimize the quantity of synthetic products sprayed by sophisticated delivery of effective substances, reduce losses of nutrients in fertilization(Marchiol *et al.*, 2020), and boost yields by optimizing water and nutrient management. Plant breeding and genetic change are also being investigated using nanotechnology-derived technologies (Ahmar *et al.*, 2021). Agriculture might potentially turn a source of bio-nanocomposites having superior physicomechanical characters based on bio-industrially collected resources like rice straw and soy hulls (Ortega *et al.*, 2021). Table 1 summarizes the most notable agricultural nanotechnology uses.

Table.1. Relevant applications of nanotechnology at the pilot scale

	Description	Example	Reference
Plant protective product	Nanocapsules, nanoemulsions, nanoparticles, andviral capsids as clever delivery vehicles of active components in plant disease management	Neem oil (*Azadirachtaindica*) Nano emulsion used as larvicidal agent (VIT University, IN)	(Anjali *et al.,* 2012)
Fertiliser	Nanocapsules, nanoparticles, and Viral capsids for improving plant nutrient uptake and delivering nutrients to targeted sites	Macronutrient Fertilizers Coated with Zinc Oxide Nanoparticles (University of Adelaide,AU CSIRO LandandWater,AU Kansas StateUniversity,US)	(Milani *et al.*, 2012)
Plant genetic modification	Nanoparticles containing DNA or RNA that has to be administered to plant cells in order to stimulate genetic change that activate defensive reactions triggered by pathogens.	Mesoporous silica nano particles transporting DNA to transform plant cells (Iowa State University, US)	(Torney *et al.*, 2007)
Nanoparticles from plants	Production of nanomaterials via the use of modified plants or microorganisms, as well as the processing of agri-waste products	Nanofibres from wheat straw and soy hulls for bio-nanocomposite production (Canadian Universities and Ontario Ministry of Agriculture, Food and Rural Affairs, CA)	(Alemdar & Sain, 2008)

In spite of these prospective advantages, nanotechnology implication in agriculture are currently meagre and have not yet had a substantial impact on the market in comparison to other industrial sectors(Neme et al., 2021). The academic sector and small enterprises seem to claim the bulk of research discoveries, although large corporations have a substantial patent portfolio (Caviggioli et al., 2020). Although the number of patent filings (mostly from agrochemical businesses) is steadily increasing, no new nano-based agricultural products have yet to hit the market(Parisi *et al*., 2015). This shows that applicants are aggressively patenting and maintaining wide patent claims to ensure future freedom to operate and exploitation in the event of viable commercial developments.

In the agricultural industry, large firms are looking at the potential of nanotech solutions (Fraceto *et al.*, 2016). Agricultural nanotechnologies, on the other hand, do not seem to have a sufficiently high commercial interest, according to industry specialists(Parisi et al., 2015). Nanotech products need huge initial expenditures that can only be offset by large-scale field applications, which are presently unavailable(Sheeparamatti et al., 2007).Industrial organizations cite regulatory concerns and public perception as factors for the difficulty of agricultural nanotechnology development at the field level(Amenta *et a*l., 2015). One of the most significant parts of regulating nanomaterials is reaching an agreement on a definition among the parties concerned, which may be standardized at the international level(Kica & Bowman, 2012). Nanomaterials seem to be difficult to define, and it isn't simply a matter of size. Particles may be aggregates, agglomerates, or nanostructured materials, and the nanoscale can be utilized in one or more dimensions (Jeevanandam et al., 2018). Furthermore, since nanotechnology is employed in a range of sectors, it is subject to many regulatory authorities and standards (Allan *et al*., 2021).

Furthermore, since nanotechnology is employed in a range of sectors, it is overseen by a number of regulatory agencies and standards(Nile *et al*., 2020). The 2019 Global The Summit provided an excellent environment for sharing the most recent information on regulatory body activities, with a focus on the application of nanotechnology in agriculture/food, nanoplastics, and nanomedicines, as well as taking stock and promoting future collaboration (Allan *et al.*, 2021). REACH (EU Regulation on the Registration, Evaluation, Authorization, and Restriction of Chemicals) is the primary EU regulation controlling nanotechnology applications(Amenta *et al.*, 2015), and there is an ongoing debate about the definition, which includes nanoparticles in aggregates and agglomerates with sizes ranging from 1 to 100 nm (Lyddy, 2009). The present EC definition does not distinguish between items that are purposefully developed to include nanoscale materials and those that are already on the market and contain such particles inadvertently(Parisi *et al.,* 2015). The proposed definition will be revised in light of new knowledge and scientific and technological breakthroughs.

Industry organizations have raised concerns about the legislation's impact, notably on labelling, public opinion, and the negative connotations it may bring to new technologies (Larsson *et al*., 2019). Consumers may reject products labelled as nano-products, and this rejection may have a retroactive effect, impacting products (such as nanoscale formulants like clay and silica) already on the market that mistakenly include nano-sized materials and hence fall inside the nano-definition (Contado, 2015).

However, consumer preference studies suggest that public opinion on nanotechnology is not typically negative, and that it is mostly influenced by perceived benefits and usability of the technology (Cobb & Macoubrie, 2004). The results show that introducing nanotech products with obvious advantages and acceptable/low risks for consumers, such as medical and environmental applications, early may increase acceptance of subsequent uses, such as pesticide solutions, where societal concerns already exist (Parisi *et al*., 2015).

II. Conclusion

Agro-nanotech breakthrough goods are having a hard time getting to market, making agriculture a marginal industry for nanotechnology. This is due to a variety of factors, including high manufacturing costs of nanotech goods, which are needed in large quantities in the agriculture sector, ambiguous technological advantages, legal uncertainty, and public opinion. Nonetheless, the R&D environment is quite promising, and nanotechnology's potential in a variety of agricultural applications is being aggressively researched. In addition, nanotechnology is rapidly advancing in other sectors. Knowledge gathered in other rising areas, such as energy and packaging, may be translated to agricultural uses over time or may produce spillovers. Improved fuel additives and lubricants, for example, might increase the performance and carbon footprint of agricultural machines, while better packaging techniques could assist farmers by decreasing product deterioration before consumption. Meanwhile, advancements in environmental monitoring and medicine delivery systems may have a favorable indirect impact on the agriculture and cattle sectors (Chen *et al*., 2013).

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