# A Study of Nanomaterials in Agricultural Field

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***ABSTRACT: Substances with at least one exterior dimension of 1 to 100 nanometers are classed as nanomaterials. Nanomaterials can develop naturally, or they can be manufactured to perform a specific function mostly by combustion processes. These substances' physical and chemical characteristics may differ from those of their bulk-form counterparts. As a result of previous technical breakthroughs, nanomaterials of various sizes and forms have been produced. These advances will provide the groundwork for future engineering to create novel characteristics that are specifically suited to certain purposes. Nanomaterials have previously been utilized safely and successfully in a range of fields, particularly food production, environmental research, and medicine. However, usage in agriculture, primarily for plant conservation and manufacturing, remains inadequately subject in the scientific community. Thus according to early study, nanomaterials have the potential to improve plant safety, seed germination and growth, disease identification, and pesticide/herbicide residue analysis. The agricultural uses of nanomaterials and their prospective significance in contemporary agricultural growth are described in this paper.***

***KEYWORDS: Agriculture, Germination, Nanomaterials, Nanoparticles, Nanotechnology.***

## 1. INTRODUCTION

In recent times, significant technological progress has been made throughout the field of agriculture to address the growing issues of sustainable development and food security. Continuous agricultural innovations, which employ natural and manmade materials, are critical in fulfilling the world's burgeoning population's growing food needs. Nanotechnology, in particular, has the potential to provide practical solutions to a wide range of agricultural challenges. Because they bridge the gap between bulk materials and molecular or atomic structures, nanomaterials are extremely important in science. In the previous two decades, a significant amount of research has been done on nanotechnology, with an emphasis on its numerous applications in agriculture. However, incorrect fertilizers usage permanently changes the chemical ecology of soil, reducing the amount of area accessible for crop production. To maintain the ecosystem and prevent many creatures from extinction, sustainable agriculture necessitates the use of the minimum agrochemicals feasible.

Nanomaterials, for example, increase crop production by increasing the quality of agricultural inputs, allowing for site-targeted, regulated distribution of nutrients with limited use of agri-inputs. Indeed, the use of nanotechnology in plant safety products has skyrocketed, potentially resulting in higher crop yields. In addition, manufacturing and the application of Nano sensors in precision farming for the purpose of calculating and monitoring crop growths, soil conditions, soil pests, agroquemical use, penetration and ecological damage have improved considerably the human surveillance and management of soil and plant health, quality management and security assurance. As a result, nanotechnology will not only minimize confusion, but also organize agricultural production management techniques as an alternative to traditional technologies. In certain cases, agro-nanotech advancements have quick solutions to problems that plague contemporary industrial agriculture.

### *1.1.Nano-Farming: An Innovative Leading Edge in Agricultural Growth:*

Nanoparticle engineering is a recent technical advancement that demonstrates unusual focused characteristics as well as increased power. Norio Taniguichi, a professor at Tokyo University of Science, invented the word "nanotechnology" in 1974 [1]. Due to the progress in their production, nanomaterials of all sizes and forms are widely used in the fields of medicine, agriculture, environmental studies and food processing. During centuries, agriculture has always learnt from these advances. Moreover nanotechnology has developed as a possible application for precision agriculture as agriculture faces numerous and unanticipated challenges such as a reduction in plant production owing to biological and abiotic stresses, the nutrient deficiency and contamination. (Figure 1).

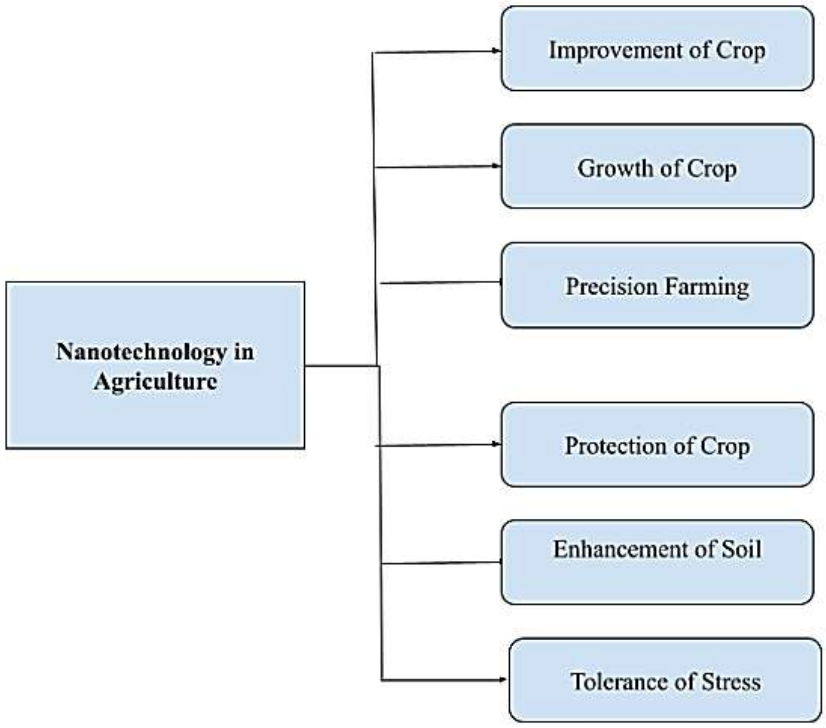


**Figure 1: The Usage of Nanotechnology in Farming. Nanotechnology Has Emerged as A Potential Application for Precision Agriculture.**

It has to do with site-specific crop management, which encompasses a broad range of pre- and post-production facets of agriculture, from horticultural crops to field crops. Nanotechnology also offers outstanding solutions to a growing host of environmental problems. The production of nano sensors, for example, has a lot of promise for tracking environmental stress and developing plants' disease-fighting abilities. As a result, continuous advances in nanotechnology, with a focus on identifying problems and developing collaborative methods for long-term agricultural growth, have the potential to have significant social and equal benefits.

*1.2.Plant Growth and Germination:*

Various researchers have been studying the impact of nanomaterials on plant germination and development in recent years in order to encourage their use in agricultural applications. Zheng et al. investigated the effects of Nano as well as non-Nano TiO2 on the development of naturally-aged seeds of spinach [2]. The scale of the nanomaterials had an inverse relationship with the rate of growth of spinach seeds, meaning that the bigger the nanomaterials, the greater the germination. The photo-sterilization and photo-generation of active oxygen like hydroxide and superoxide anions by nanoTiO2 which can boost seed stress resistance and encourage capsule penetration for ingestion of oxygen and water required for quick germination may be the main explanation for the increased growth rate. The authors accepted that TiO2's Nano size could have improved inorganic nutrient absorption, accelerated organic material breakdown, and caused quenching of oxygen free radicals produced during the photosynthetic process, resulting in an increase in photosynthetic rate.

The penetration of nanomaterials into the seed is the key to improved seed germination rate. Khodakovskaya et al. found that MWCNTs can infiltrate tomato seeds and increase germination rate by raising seed water uptake [3]. A study of the effect of metal nanoparticles on lettuce seed germination found that nanoparticles had a positive effect on seed germination, as measured by the shoot to root ratio and seedling development. The authors have wanted to work out whether the nanoparticles have some impact on soil microorganisms, but they couldn't find something definitive.

The potential of fluorescein isothiocyanate (FTIC)-labeled silica nanoparticles and photo stable Cadmium-Selenide (CdSe) quantum dots to act as bio labels and promote seed germination was investigated. FTIC-labeled silica nanoparticles were found to cause seed germination in corn, while quantum dots stopped it. Lin and Xing studied Nanomaterial phytotoxicity and its effect on germination rates in radish, canola, rapeseed, ryegrass, corn, lettuce, and cucumber.

The results of four oxide nanoparticles on the plant species radish, tomato, rape, lettuce, cabbage, wheat, and cucumber were investigated by Ma et al. [4]. They discovered that root growth was influenced by nanoparticles and their concentration, similar to the study of Lin and Xing. Furthermore, the nanoparticles' inhibitory activity was observed at various stages of root development. Thus, before using nanomaterials in the field, the phytotoxic activity of the nanomaterials must be fully understood. Growing plant seedlings in a greenhouse and then moving them to the field may be one way to prevent phytotoxicity to other plant organisms. Ornamental and specialty crops will benefit from this.

The EPA is debating the applicability and phytotoxicity of silver nanomaterials in agriculture. According to M. Murphey et al. Ag is present in over 100 pesticides owing to its antimicrobial properties [5]. The toxicity of Nano-silver to ecosystems and humans, on the other hand, is a significant concern. Citrate-coated colloidal Ag nanoparticles were not genotoxic, phototoxic or cytotoxic to humans, according to Lu et al. (2010), but citrate-coated Ag nanoparticles in powder shape were [6]. This may be due to the "chemical transition of the nanoparticle of spherical silver in the form of powder to create silver oxides or ions". Surprisingly, coating the powdered Ag nanoparticles with biocompatible polyvinylpyrrole reduced their photoxicity. Exploring biocompatible coatings to reverse Nanomaterial toxicity will improve the likelihood of nanomaterials being used in plant germination and development.

According to Oancea et al. the regulated release of active plant growth stimulators and other chemicals encapsulated in Nano-composites consisting of layered double hydroxides, may be another viable choice for organic agriculture [7]. Leading food organic certifiers, on the other hand, refuse to accept Nanomaterial-based agri-foods as organic. Naturland and the International Federation of Organic Agriculture Movements (IFOAM), both headquartered in Germany, recently banned the labeling of food products grown with artificial nanomaterials as organic. Future research on nanomaterials for plant germination and development should, however, discuss the following issues:

- Unpredictability of nanomaterials' reactions to various species,
- Phytotoxicity as a result of higher concentrations, and
- Decreased photosynthesis as a result of larger nanomaterials.

### *1.3.Smart Delivery Options Enabled by Nanoparticles:*

Nanotechnology is considered to be one of the most important breakthroughs of the 21st century that may promote traditional farming and offer sustainable output through improved management and recycling techniques, and a reduction in agricultural input waste. As a consequence, only a tiny proportion of agrochemicals reach crop targets far lower than the lowest effective plant growth concentration predicted. The variables that contribute to the losses include chemical leaching, hydrolysis, photolysis and microbiological decline. For example, when applying fertilizer, more attention should be paid to the bioavailability of nutrients as a result of soil chelation, microorganism depletion, hydrolysis, and run-off issues. Nanomaterials boost agrochemical stability and shield them from oxidation and eventual release into the atmosphere, resulting in improved efficacy and lower agrochemical volumes.

Apart from agricultural uses, the integration of nanotechnology and biotechnology opens up new avenues for gene modification and even the development of new species as new molecular transporter methods (Figure 2). Nano-biotechnologies, for example, use nanoparticles, nanocapsules, and nanofibres to transport foreign DNA and chemicals that help alter target genes. Viral gene delivery vectors face various challenges during the delivery of genetic materials, including a restricted host selection, a limited size of injected genetic material, and transportation across the cell membrane, and a nucleus trafficking problem. Silicon dioxide nanoparticles have been developed in genetic engineering to transmit DNA fragments/sequences to target organisms such as tobacco and corn plants without causing any unwanted side effects. Nanomaterials, it turns out, could reduce off-target effects by increasing the reliability and precision of CRISPR/Cas systems. For instance, in cultured cell lines, cationic arginine gold nanoparticles assembled Cas9En (E-tag)-RNP distribution of sgRNA provides around 30% effective cytoplasmic/nuclear gene editing ability, which would greatly aid future crop development research.

### *1.4.Detection of Plant Pathogen:*

"Smart field systems diagnose, identify, and report pathogens, then apply pesticides and fertilizers as appropriate before symptoms appear," according to the researchers. While this study is still in its early stages, nanoparticles have the potential to be used as biomarkers or as a rapid diagnostic method for the identification of bacterial, virus, and fungal plant pathogens in agriculture. In plants that have greater detection limits, Nanoparticle-based sensors might recognize viral infections. Specifically tailored for the detection of infections or a screening tool for identifying chemicals that show an illness state, nanoparticles can be employed. Capturing samples of fluorescent oligo, to be utilised for hybridization detection, are microarrays[8]. Singh et al. used surface plasmon resonance (SPR) to detect Karnal bunt disease in wheat using Nano-gold Immunosensors [9]. The study focused on using an SPR sensor to diagnose the disease in wheat plots for seed certification and plant quarantines. Pathogen sensing nanosensors for infield use can be extremely beneficial for rapid disease identification and control.

Physiological modifications occur in plants in response to various stress conditions. The activation of systemic protection is one such reaction that is thought to be controlled by plant hormones such as jasmonic acid, methyl jasmonate, and salicylic acid. Wang et al. used this indirect stimulus to create a sensitive electrochemical sensor that monitors salicylic acid levels in oil seeds to detect fungi, using a modified gold electrode with copper nanoparticles [10]. Using this sensor, they were able to reliably test salicylic acid. Related sensors and sensing methods should be studied further for detecting pathogens and their byproducts, as well as tracking physiological changes in plants.

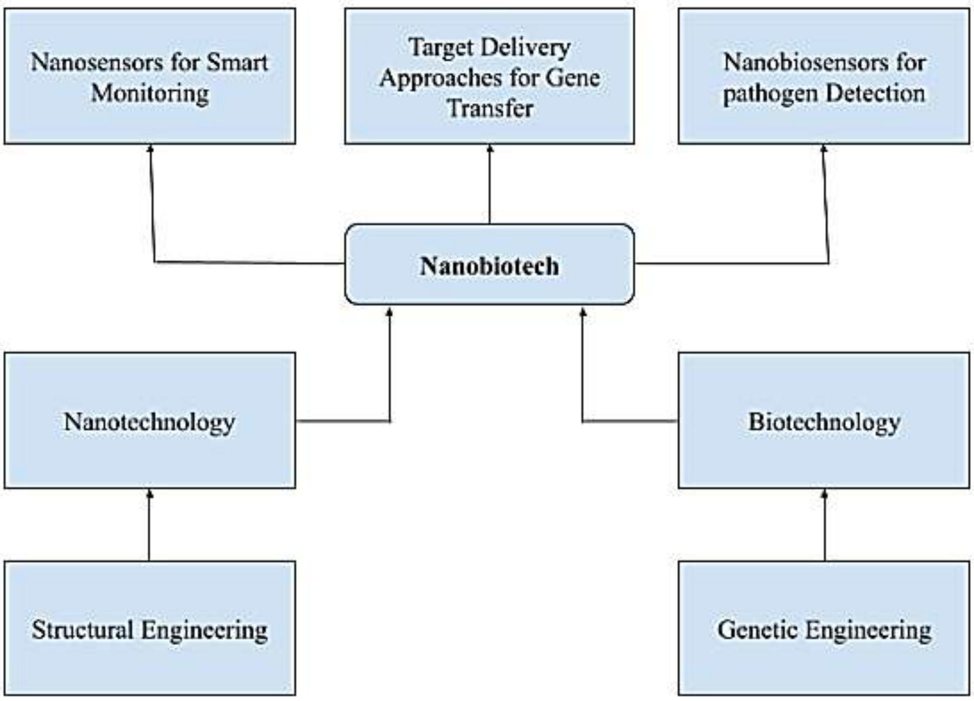


**Figure 2: The Physical Layout of Nano-Biotechnology. Nano-Biotechnologies Use Nanoparticles, Nanocapsules, and Nanofibres to Transport Foreign DNA**

*1.5.Drawbacks and Future Research Requirements:*

Any of the main issues for using nanomaterials in agriculture include ecosystem toxicity, possible residual carry-over in crops, and Nanomaterial phytotoxicity. Bouwmeester et al. examined the health risks of nanomaterials used in plant processing in depth [11]. Furthermore, the "toxicodynamics and toxicokinetics" of nanomaterials used in agricultural processing must be measured. According to R. Jayakumar et al. the same nanomaterials have differing effects on different agricultural plants and, if not degraded rapidly, would have a significant impact on alternate cropping systems [12]. Until using nanomaterials in agricultural production processes, research on these subjects must be undertaken and their effects fully understood. Site-specific Nanomaterial application technology will mitigate any of these threats. The following are the main concerns concerning the use of nanomaterials in agricultural processing and crop protection:

- Precise characterization of nanomaterials in biological matrices for a thorough understanding of their toxicity in biological environments,
- Nanomaterials interactions with biology,
- Dose response considerations

- Research on exposure measurement and characterization,
- Commodity life cycle factors,
- Context amounts of nanomaterials in food and feed matrices, and
- Nanomaterial number and type in foodstuff as a result of their use in agricultural production and crop protection.

Low-cost nanomaterials and field application technologies, like other technologies, are needed for agricultural applications. According to Navarro et al. detailed studies on nanomaterials aspects such as nanoparticle dosage in various environments, their physical and chemical characterization, the mechanisms allowing them to pass across cellular membranes and cell walls, the specific properties that are related to nanoparticle toxic effects and the mechanism underlying nanoparticle trophic are all being conducted [13]. To conclude, the creation of nanomaterials that are much dispersed and wettable, biodegradable, less poisonous, and more photo generative in soil and environment, well-understood toxicokinetics, smart and sturdy, are simple to manufacture and use in agriculture, ideal for usage successfully in farming.

## 2. DISCUSSION

Nanotechnology and biotechnology have combined a wide range of applications in a variety of areas for nanomaterials. Nanomaterials based on carbon, metal and metal oxide have been developed to include Nano-sized polymers and bio-composites. The many types of nanotubes are single-walled and multi-walled, magnetic nanoparticles of iron, copper, aluminum, gold, silica, zinc, zinc nanoparticles, cerium oxide, and titanium oxide. All illustrations of the general uses for these goods include water purification, wastewater waste disposal, food processing and packaging, environmental restoration, industrial and home usage, pharmacy and smart sensor manufacture. This study therefore summarizes the finding and deployment of new nanomaterials in agriculture. The subjects covered in this article include plants and growth, plant safety and productivity, pesticide/herbicide residue detection and disease identification.

## 3. CONCLUSION

The emphasis of this study was on basic applications of nanomaterials in agriculture, such as plant safety, pathogen detection, and pesticide residue detection. In comparison to conventional methods, nanomaterials can help with faster plant germination/production, better plant safety, and decreased environmental effects. Smart Nano sensors may also be an effective way to identify pesticide residues in the field. This study also addressed some of the problems and questions related to particular Nanomaterial applications, as well as a few potential solutions. Nanomaterials, for example, can increase plant germination in certain plants while damaging other plants. In such situations, nanomaterials may be used to facilitate germination in the plants of interest under regulated conditions like in greenhouse-grown plants. Despite the fact that this analysis shows the promise of nanomaterials for a range of agricultural applications, further study and investigation is needed to extend the application possibilities and methodologies in agriculture. In conclusion, the invention of nanomaterials that have strong dispersion and wettability, are biodegradable in soil and the environment, are less toxic and more photo-generative, have well-understood toxicokinetics and toxicodynamics, are smart and robust, and are simple to fabricate and apply in agriculture which will be perfect for their successful use in agricultural production.

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