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The Application of Nanomaterials with in Farming Industry

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ABSTRACT: Nanomaterials having at least one exterior dimension of 1 to 100 nanometers are classed as materials. Nanomaterials may arise or develop naturally or be manufactured to perform a particular function as by-products of combustion processes. The physical and chemical characteristics of these materials may differ from the counterparts of their bulk form. As a consequence of recent technical developments, nanomaterials of different sizes and forms were produced. These discoveries will serve as a basis for future engineering to develop new characteristics suited to specific applications. Nanomaterials have been utilized in a number of previous sectors, including food production, environmental research and medical, in an effective and secure manner. In the scientific community, however, the application in agriculture is under-explored, especially in plant conservation and processing. Nanomaterials are, according to early study, capable of improving plant safety, germination and development in seeds, identification of pathogens and detection of pesticide/herbicide residues. This research covers the agricultural uses of nanomaterials and their prospective significance in future agricultural development.

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

I. INTRODUCTION

To meet the mounting issues of sustainable development as well as food security, significant agricultural technical improvements have been made in recent years. By using natural and synthetic materials, these ongoing agricultural advances are crucial to fulfilling the world's growing population's rising need for food. In particular, nanotechnology may provide helpful solutions to a number of agricultural problems. To put it simply: nanoparticles close the gap among bulk materials as well as molecular or atomic structures. Agricultural nanotechnology has been the subject of a large amount of research over the last two decades. Increasing farm productivity requires the use of fertilizer; however, inappropriate application of fertilizer permanently changes soil chemical ecology and reduces the quantity of soil accessible to crop development. Sustainable agriculture needs the least possible use of agrochemicals to preserve the environment and prevent different species from extinction [1].

For example, nanomaterials improve crop yield by improving the quality of agricultural inputs and enable the localized, controlled delivery of nutrients using a small number of agri-inputs. Nanomaterials Nanotechnology has indeed been used in plant safety products, leading to better crop yields. In agriculture, it is also a major challenge to enable plants to address progressive climate change factors such as high temperatures, water shortages, alkalinity, salt and radioactive metal waste more rapidly, without jeopardizing current sensitive habitats. In addition, manufactures and uses of nanosensors in precision farming have significantly improved human soil and plant health monitoring, quality management and safety assurance in the calculation and control of crop growth, soil conditions and pests, and environmental decomposition, all of which have contributed significantly to sustainable agriculture and environmental systems. High-tech agricultural fields benefit from nanomaterials engineering, which provides a wider specific surface area that is critical to the long-term viability of farming systems. To put it another way, nanotechnology is an alternative to traditional technologies that not only reduces uncertainty, but also organizes agricultural production. In certain instances, the advances in agro-nanotechnology offer fast answers to the issues that afflict modern industrial agriculture [2].

Nanomaterials are defined as materials of less than 100 nm particle size in a single dimension. The marriage of nanotechnology and biotechnology has significantly expanded the spectrum of nanomaterial applications in a number of areas. Nanomaterials based on carbon, metal and metal oxides are being developed for Nano-sized polymers and bio-composites. There are a variety of types of single walled and multi-walled carbon nanoparticles, magnetized iron (Fe), copper (Cu), aluminum (Al), gold (Au), silica (Si), zinc (Zn) and zinc oxide (ZnO), cerium oxide ($Ce2O3$) and titanium dioxide ($TiO2$). The typical uses for such goods are all instances of waters purification, wastewater disposal, food processing and packaging, environmental remediation, industrial and home usage, pharmacy and intelligent sensor manufacturing. Most of these projects have stressed the significance of nanomaterials for improved performance and productivity. These products are also utilized in crop protection and farming.

Systematic literature evaluations have been conducted as a roadmap to the ongoing progress of nanomaterial technology. The article examines water disinfection, food industry, the control of non-point emissions from sources, the disposal of environmental waste and development of trace concentration monitoring systems. On the other hand, the use of nanomaterials in agriculture is very new and calls for more research. There have been no previous literature investigations. This document summarizes the discovery and application of new nanomaterials in agriculture. The subjects addressed in this article include plant germination and development, plant safety and productivity, pesticide/herbicide residue detection and pathogen identification [3].

A. Nano-farming

Nanoparticle engineering is a new technological breakthrough which shows unique focus and power properties. The term 'nanotechnology' was coined by Norio Taniguichi, professor at the Tokyo University of Science, in 1974. While the term 'nanotechnology' has long been used in a number of areas, it is still a very recent technological development which is being established that nanoparticles (NPs) may be helpful in agricultural productivity. Due to its development, nanomaterials of different sizes and forms have a broad variety of applications in health, agriculture, environmental sciences and food production. Farming has always benefited from these advances in technology. The potential uses of nanotechnology for precision agriculture have also developed as a result of agriculture's numerous and unanticipated issues, such as decreasing crop yields due to biotic or abiotic pressure, nutrient shortages, as well as pollution.

In recent years the phrase "precision agriculture" or "farming" is popular with wireless networking innovation and sensor miniaturization in order to monitor, evaluate and regulate agricultural activities. It is concerned with site-specific crop management, which comprises a wide variety of aspects of agriculture before and after production, from horticultural crops to field crops. Recent advancements in tissue engineering and engineered nanomaterials-based selective supply of seed genetic engineering (CRISPR) mRNA and sgRNA (GM) for CRISPR (clustered regularly interspaced short palindromic repeats), are remarkable scientific accomplishments. Nanotechnology also provides excellent answers to an increasing number of environmental issues. For example, the creation of nanosensors is very promising to monitor environmental stress and to improve the ability of plants to resist illness. As a consequence, continued progress in nanotechnology, with an emphasis on recognizing issues and creating collaborative ways for sustainable agricultural development, has the potential for substantial social and equitable advantages [4].

B. Plant Growth and Germination

In recent years, many researchers studied the effect of nanomaterials on plant germination and development to promote their usage in agricultural applications. Researchers examined the impacts of Nano and non-Nano TiO_2 on natural-age spinach seeds. Throughout 30 days of germination, the treated seeds Nano-TiO_2 supplied 73 percent dry weight, the photosynthesis rate three times higher and chlorophyll production 45 percent greater than control seeds. The nanomaterial size exhibited an inverse connection to the spinach seeds growth rate, which means that the larger the nanomaterials, the higher the germination rate. The main reason for the increasing rate of development is the photo-sterilization and photo generation of active oxygen such as hydroxide and nanoTiO_2 superoxide anions, which can boost seed stress resistance and encourage capsular penetration for intakes of oxygen and water required for rapid germination. The scientists agreed that the TiO_2 Nano-size may have enhanced the absorption of inorganic nutrients, speeded up the breakdown of organic material and induced oxygen-free radicals, which were created during the photosynthetic process, to boost photosynthetic rate.

Nanomaterial penetration into the seed is essential to improving seed germination. MWCNTs were shown to penetrate tomato seeds and improve the rate of germination by increasing the absorption of seeds. In just 20 days, MWCNTs raised seed germination by up to 90% as well as plant biomass. The scientists stressed, however, the need of additional investigation into the pest tolerance of CNT germinated tomato plants and the harmful effects of CNT on other field plants before applying CNT directly on site. A research on the effects of metal nanoparticles on germination of lettuce seeds showed that nanoparticles had a favorable impact on germination by shooting and seedling. The scientists sought to see whether the nanoparticles had any effect on microbes in the soil, but nothing conclusive could be found [5].

Positive or negative impacts of nanoparticles on plants may occur. One of the problems is the phytotoxicity of nanomaterials employed in seed germination. The degrees of phytotoxicity may vary based on the kind and planned usage of the nanomaterial. It examined the potential of the nanoparticles tagged Fluorescein Isothiocyanate (FTIC) and photostable Cadmium Selenide (CdSe) quantum points, which serve as biolabels and encourage seed germination. The germination of seed in maize caused by FTIC-labeled silica nanoparticles, whereas quantum dots prevented it.

Nanomaterial phytotoxicity and its impact on radish, canola, rapeseed, ryegrass, maize, lettuce and cucumber have been investigated by Lin and Xing. They found that greater levels of Nano-size Zn (35 nm) and ZnO (w20 nm) inhibited germination in ryegrass and maize at 2000 mg/L, respectively. The usage of Nano-Zn and ZnO 200mg/L reduced the root length of the plants examined. The fitness of Nano-Al and Nano-Al Tetra has significantly affected the root elongation of ryegrass and rice, respectively, while Nano-Al helped the root development of radish and rape.

Researchers have examined the effects of four oxide nanoparticles on radishes, tomatoes, rape, lettuce, cabbage, wheat and cucumber of plants. They found that nanoparticles and their concentration impacted root development similar to the Lin and Xing research. With the exception of lettuce at the 2000 mg/L dosage, researchers found that nano-CeO_2 had a minimal influence on plant root elongation. The other three types of nanoparticles (La_2O_3, Gd_2O_3 and Yb_2O_3) nevertheless had a significant effect on root development at the same concentration. In addition, inhibitory action of nanoparticles was found at different phases of root growth. The phytotoxic activity of the nanoparticles must thus be thoroughly studied before employing nanomaterials in the field. Growing plant plants into a greenhouse and transferring them to the field may be a method of preventing the plant organisms from becoming phytotoxic. This will help ornamental and specialty crops [6].

The EPA discusses how silver nanoparticles may be used and phytotoxic in agriculture. According to researchers Ag, its antibacterial characteristics have resulted in over 100 insecticides. On the other hand, the toxicity of Nano-silver to ecosystems and people is a major issue. Citrate-coated nanoparticles Ag were not, according to researchers, genotoxic, or phototoxic to humans, but citrate-coated Ag powder-shaped nanoparticles. This may be caused by the "chemical transformation of the spherical silver nanoparticle into powder to produce silver oxides or ions." Surprisingly, the photoxicity was decreased by the coating of powdered Ag nanoparticles with biocompatible polyvinylpyrrole. Biocompatible coating exploration to reverse the toxicity of Nanomaterials will increase the probability of the employment of nanomaterials in plant germination and development. Research must also examine the detrimental impact on intended seed/plant characteristics and nanomaterial efficacy of such coatings [7].

According to researchers controlled release of active plant growth stimulants and other Nano-composite compounds, comprised of layered double hydroxide, may be another feasible option for organic farming. On the other hand, leading certifiers on organic foods refuse to certify agri-foods based on nanomaterials as organic. Naturland and IFOAM, both based at German level, have prohibited the designation of foodstuffs produced using artificial nanomaterials as organic. The following problems should still be addressed in future research into nanoparticles for plant germination and development: Nanomaterial responses to different species are unpredictable, greater amounts of phytotoxicity, and Lower photosynthesis due to bigger nanomaterials.

Nanoparticles Enabled Intelligent Delivery Options:

Nanotechnology is considered to be one of the most significant breakthroughs of the 21st century, capable of promoting conventional agriculture and providing sustainable output, by improving management and recycling techniques and decreasing agricultural waste. Sustainable agricultural processing and precision farming are important elements of agrochemical and organic modules delivery systems, as well as of the transfer of DNA molecules or oligonucleotides into plant cells. Normally, agrochemicals are applied to crops via conventional methods like spray and/or diffusion. This means only a tiny proportion of agrochemicals reach plant target locations far below the minimal effective plant growth concentration anticipated. All factors contributing to losses include chemical leaching, hydrolysis, photolysis, and microbiological degradation. For example, greater attention should be given to the nutrient bioavailability of soil chelation, microbial depletion, hydrolysis and runoff problems while applying fertilizer. The focus should be on increasing efficacy via spray drift management in the case of pesticide applications. As a way to ensure environmentally sound agriculture, researchers using nanotechnology are creating fertilizers, herbicides, and insecticides that release at regulated or delayed times. Throughout history, nanotechnology has progressed from laboratory-based research to real-world use cases. It is the purpose of controlled dispensing systems to ensure that agrochemicals are dispensed in the correct quantity and at the correct time to maximize biological competence while reducing waste and negative consequences. Because of their huge surface area, simplicity of binding, and quick mass transfer, nanoparticles are ideal for dispersing agrochemicals. A variety of mechanisms include the entangling of active substances in the Nano-Matrix, absorption, capsulation, and weak bond attachments or surface Ionics in agrochemicals. In large scale developments the encapsulation of potassium nitrate via graphene oxide sheets substantially in theory, a low-cost fertilizer formulation like this one might be made to limit the release of fertilizer. Enhancing the stability of agrochemicals and protecting them from oxidation as well as eventual disposal of wastes, nanomaterials improve agrochemical performance and reduce agrochemical quantities. [8].

In addition to agricultural application, nanotechnology and biotechnology integration offer up new possibilities for gene change and potentially the creation of new species as novel molecular transport systems. Nano-biotechnologies, for example, carry foreign DNA and substances that assist change target genes via nanoparticles, nanocapsules, and nanofibers. The delivery of genetic materials by viral genes involves a limited host selection, the limiting size of the injected genetic material, transportation across the cell membrane, and an issue of nucleus trafficking. Recent advances in Nano-biotechnology offer researchers greater opportunities to completely replace one animal's genetic makeup with another. Silicon dioxide nanoparticles in genetic engineering have been created to transfer DNA fragments/sequences to target species such as tobacco or maize plants without producing any adverse side effects. The tolerant new kinds of insects are also produced utilizing the NP-assisted technique of supply. For example, with gene-gun technology, DNA-coated NPs are used to blast cells or tissues to transfer the desired genes to targeted plants. Since Chitosan has an excellent RNA binding capacity and the ability to enter cell membranes, current research in SiRNA delivery vehicles encroached on chitosan NPs has produced a new plot enhancement that will enable target control of insect pests. Thanks to the recent advances in the selective delivery of CRISPR/Cas9 single guide RNA, a new era of genetic engineering has begun (sgRNA). CRISPR/Cas9 is a prokaryotic RNA-driven protective system extensively utilized in plant genome editing. It comprises of repeat-spacer arrays and proteins from CRISPR. However, the low dependability of distribution remains a major barrier to its adoption. It turns found that nanomaterials may minimize off-target impacts by improving CRISPR/Cas systems dependability and accuracy. For example, Cas9En (E-tag)-RNP (ribonucleoprotein) distribution of sgRNA in cultivated cell lines offers approximately 30% efficient cytoplasmic/nuclear gene editing capabilities, significantly supporting future crop development research [9].

C. Plant Pathogen Detection

"Intelligent field systems detect, identify, and report infections and, if appropriate, administer pesticides and fertilizer before symptoms emerge," the researchers said. While this research is still in its early stages, nanoparticles may be utilized for the detection of pathogens in bacterium, viral, and fungal plants in agriculture as biomarkers or a speedy diagnostic technique. Nanoparticle-based sensors may be used in plants with better detection limits to identify viral infections. Nanoparticles may be tailored particularly to detect infections or used as a tool to identify chemicals that signal a condition. Nano-chips are micro-arrays containing samples for the detection of hybridization that are fluorescent to oligo capture. The sensitivity and precision of the Nano-chips above are well recognized in the detection of nucleotide changes in bacteria and viruses. A bacterium that produces a bacterial spot disease in Solanaceae plants, which suggests that nanoparticles may be helpful in detecting illness, Xanthomonas axonopodis vesicatoria, is a bacterium that utilizes nanoparticles in combination with antibodies. Surface Plasmon Resonance (SPR) has been used by researchers in detecting carnal bunt disease in wheat using Nano-gold Immunosensors. The research emphasized the diagnosis of the illness on wheat plots for seed and plant quarantines using an SPR sensor. Pathogen detecting nanosensors for infield usage may be very helpful in identifying and controlling quick diseases.

In plants, physiological changes occur in response to different stress situations. The activation of systemic protection is one such response that plant hormones such as jasmonic acid, methyl jasmonate and salicylic acid are believed to regulate. This indirect stimulus was utilized by researchers to develop a vulnerable electrochemical sensor that detects fungal salicylic acid in oil seeds by utilizing a modified gold electrode with copper nanoparticles. They were able to accurately test salicylic acid using this sensor. For the detection of infections and their byproducts, and the monitoring of physiological changes in plants, related sensors and sensing processes should be further explored [10].

D. Future Research

The major problems for the use of nanoparticles in agriculture are environmental toxicity, potential residual transportation of crops and the phytotoxicity of nanomaterials. Researchers investigated in detail the health hazards of plant treatment nanoparticles. Kahru and Dubourguier have also investigated the health hazards of various nanomaterials. In addition, the nanomaterials employed in agricultural processing must be assessed by the toxicodynamics and toxicokinetics. According to researchers the same nanomaterials have various impacts on different farm plants and might have an important influence on alternative crop systems if not destroyed quickly. Until nanomaterials are used in processes of agricultural production, study must be conducted on these topics and their impacts thoroughly understood. Any of these risks will be mitigated using site-specific nanomaterial application technology. The major issues with the use of nanoparticles in agriculture and crop protection are as follows:

Accurate characterization of biological matrix nanomaterials to provide comprehensive knowledge of their biological toxicity,
Interactions between nanomaterials and biology,
Considerations of dose response
Exposure measurement and characterization research,
Factors of the commodity life cycle,
Context quantities of nanoparticles in food and feedstuffs and
The quantity and kind of nanomaterial in foodstuffs as a consequence of their usage in agricultural production and crop protection.

II. DISCUSSION

Like other technologies, low-cost nanomaterials and field applications technologies are required for agricultural applications. Existing implementing methods must be examined in order to enhance the efficiency of nanomaterials/Nano-pesticides on their intended targets. Models for predicting Nanomaterial exposure limits and scenarios including transportation, transformation and toxicity assessment characteristics of each nanomaterial, comparable to the pesticide drift assessment models, are needed. According to researchers, detailed studies of nanomaterials aspects such as the dosage of nanoparticles in different environments, their physical and chemical characterization, mechanisms for transferring them across cell membranes and cell walls and the specific characteristics associated with nanoparticles are all performed. Many researchers, notably researchers, have shown the hazards to human health of nanomaterials. Inhalation, swallowing and cutaneous absorption absorb nanomaterials into the human body. Researchers stressed the significance of studying variables for their human exposure impacts, such as nanomaterial size, surface structure, chemicals, solubility and aggregation. If effective nanomaterial application methods are utilized in agricultural processing, this potential for exposure may be minimized. In conclusion, the invention of nanomaterials with a high dispersion are soil and environmentally biodegradable, less toxic and more photo-generative, have good understanding of toxicokinetics and toxicodynamics, are intelligent, robust and easy for manufacturing and application in agriculture, which are perfect for successful use in agricultural production.

III. CONCLUSION

The focus of this research was on fundamental agricultural uses of nanomaterials, such as plant safety, the detection of pathogens and pesticide residues. Nanomaterials may assist quicker plant germination/production, greater plant safety and lower environmental impacts compared to traditional techniques. Intelligent nanosensors may also be an efficient method of identifying pesticide residues in the field. This research also addressed certain issues and concerns relating to specific uses of nanomaterials and a number of possible solutions. For example, nanomaterials may enhance the germination of plants in some plants while harming other plants. Nanomaterials may be utilized to promote germination in interest plants under controlled circumstances such as in greenhouse-grown plants in such scenarios. Although this analysis indicates that nanomaterials are promising for a number of agricultural applications, more studies and research are necessary in order to increase application possibilities and methods in agriculture.

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