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NANOPARTICLES FOR GROWTH PROMOTION AND MANAGEMENT OF DISEASE IN MILLETS

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ABSTRACT

Pearl millet is susceptible to a number of diseases, the most damaging of which is downy mildew, which is caused by the fungus Scelopori graminicola and leads to a reduction in the amount of grain and fodder produced. Nanoparticles have recently risen to the forefront of discussion as a potentially useful tool for the prevention and treatment of diseases in agricultural settings. In the course of this research, green zinc oxide nanoparticles were manufactured and tested to see whether or not they are effective at preventing the growth of downy mildew. During the manufacturing process of zinc oxide nanoparticles, a saponin-rich fraction that was obtained from an aqueous extract of Eclipta alba was utilized. In order to conduct an investigation of the produced nanoparticles, a number of distinct methods, such as UV spectroscopy, FTIR, SEM, XRD, DLS, and EDAX, were utilized. Pearl millet seeds that were treated with synthetic nanoparticles (NP) resulted in a considerable increase in germination rates, plant vitality, plant height, and both the wet and dry weight of seedlings when grown in the laboratory and greenhouse. Researchers found that treated seedlings with nanoparticles had significantly higher zinc concentrations when compared to control seedlings. This was determined by analyzing zinc levels in both treated and control seedlings. The results of the sporicidal assay of ZnO NP showed that treatment with 50 ppm of nanoparticles generated plasmolysis and inhibited the spore germination of S. graminicola zoospore.

Keywords: *graminicola, nanoparticle, Nanotechnology*

INTRODUCTION

A nanoparticle is an extremely small unit, the size of which are measured in nanometers. These nanoparticles can be found in nature, and they can also be manufactured artificially for use in a variety of applications, including medical, engineering, agriculture, and environmental remediation, among others. Nanotechnology refers to the in-depth study of particles on this small scale.

Nanotechnology has made significant strides in the fields of health and pharmacology, but it has garnered a comparably lower level of interest for its applications in agriculture. In the field of agriculture, nanotechnology is now being researched for its potential applications in the areas of plant hormone administration, seed germination, water management, the transfer of target genes, nano barcoding, nano sensors, and controlled release of agricultural pesticides. Adopting the most recent technology, the major focus of which is on improving agricultural output, has emerged as a need in today's world. In recent times, the concepts of nutritional security and food have been thoroughly ingrained in the conventional body of knowledge. Among the many other factors that influence the development of the agriculture sector, health, social inclusion, natural resource management, energy conservation, ecosystem procedure, etc., should also be addressed to specific target-oriented goals. As a result, sustainable agriculture is an essential component to eradicating poverty and hunger among the people. Nanotechnology and other cutting-edge scientific fields will play a critical role in determining how far and how quickly sustainable agriculture advances.

DEVELOPMENT OF AGRICULTURE

In spite of the fact that the word "nanotechnology" has been in use in a broad variety of sectors for quite some time, the production of nano particles may also be used to the field of agriculture. Considering that this is a relatively new breakthrough, it warrants more research. As a result of recent developments and the ability to control the size and structure of the particles and, as a consequence, govern the properties of the material, prospective industries have opened up, including the fields of agriculture, medical, and environmental sciences. These new fields have the potential to make significant contributions to society.

These technologies undoubtedly have the potential to be advantageous to the agricultural sector and have the ability to aid in the resolution of complex problems such as lower quality yields as a result of the repercussions of biotic and abiotic stress. Other considerations, such as inadequacies in nutrition, environmental circumstances, and air pollution, might also be taken into account. In addition to making, it possible for agricultural methods to be more precise, the further development of nanotechnology can be of assistance in reducing the severity of these repercussions or perhaps removing them entirely.

In recent years, there has been an increase in the popularity of precision agriculture and farming, as well as the fabrication of wireless networking and the shrinking of sensors. All of these developments are meant to monitor, analyze, and regulate agricultural operations. In instance, special criteria for site management may be applied to both the pre and post agricultural production aspects of a given circumstance. This is possible since agricultural production is a continuous process. Recent developments in tissue engineering, such CRISPR/CAS mRNA and sgRNA, have the potential to have enormous implications, which may be proved through scientific study. These implications have the potential to have major effects.

NANOTECHNOLOGY

Nanotechnology is a new scientific approach that involves the use of materials and equipment that are capable of using the physical and chemical properties of a substance at molecular levels to explore the biological and material worlds in nanometer-scale and use it in a variety of carriers, ranging from medicine to agriculture. The term "nanotechnology" was first coined in the 1990s to describe this emerging field of study.

PROPERTIES OF THE NANOPARTICLES

Increased relative surface area and quantum effects are the two key contributors to the huge changes in features that may be noticed between nanoparticles and other types of materials. These differences may be seen when comparing nanomaterials to other types of materials. Properties such as morphology-aspect ratio / size, hydrophobicity, toxic material solubility release, surface area / ruggedness, contamination / adsorption of surface species during synthesis / history, important reactive properties of nanoparticles with oxygen species (ROS) O2/H2O, ROS production capacity, structure / composition, competitive receptor binding sites, and dispersion / aggregation are all examples of properties that can be altered and modified depending on what is required.

The term "generic technology" is widely used to allude to nanotechnology, which is the study of matter on a nanoscale (1-100 nm) and delivers goods that are better-built, safer, longer-lasting, cost-effective, and intelligent. Nanotechnology deals with matter on a nanoscale. The consumer goods, communications, medical, agricultural, and food sectors are only some of the markets that stand to benefit greatly from the use of these products. Nano-fertilizers, nano-herbicides, nano-pesticides, removing recalcitrant contaminants from water, nano-scale carriers, nanosensors, veterinary care, fisheries and aquaculture, detection of nutrient deficiencies, preservation, photocatalysis, nanobarcodes, quantum dots, and many other things are examples of products and applications in agriculture that are based on nanotechnology.

OBJECTIVES

1. Evaluate the effectiveness of nanomaterials in enhancing crop yield and productivity in millet plants.
2. Assess the potential of nanobiotechnology in managing diseases and pests affecting millet crops.

METHODOLOGY

These nanocomposites have a tremendous amount of potential for use in a variety of applications, including green catalysis, gas sensors, biosensors, capacitors, and nanoelectronics. These NCs also have a number of uses in biomedicine, including health and growth, enzyme immobilization, protein stability, prevention of protein aggregation, and a drug delivery method, amongst many others. After that, FTIR measurements were used to analyze the nanoclays in terms of their characteristic peaks and the stretching of their bonds. FTIR spectroscopy was performed with a resolution of 2 cm-1 in the range of 400–4000 cm-1 using a Bruker Tensor 37 FTIR spectrophotometer. FTIR is utilized so that the characteristic peak of the minerals can be determined. The crystalline nature of nanoclays and their 2 theta values were investigated using a Rigaku Ultima-IV desktop X-Ray diffractometer with Cu K radiation (= 1.540562) radiation in the range of 5-80 degrees (2). The software Origin Ro 9.0 was used to fit the peak and examine the peak properties.

DATA ANALYSIS

These hybrid materials use POPD as the matrix and MMT nanomaterial as the nanofiller in one case (POPD: MMT NCs), and by taking the POPD as filler in the other case (MMT: POPD NCs), respectively. As a result, the study of four distinct nanoclays, each of which has its own set of features, as well as the anti-aggregation potential of each, is included in this chapter. For the purpose of the production of polymer-based nanocomposites, a screening was carried out to identify the most effective nanoclay, which possessed an improved property.

Table 4.1.1: A graphical representation of the zeta potential of four distinct nanoclays

Nanoclay	Zeta Potential (mV)
MMT K-10	-28.1
MMT K-30	-18.1
Halloysite Nanoclay	-28

Bentonite Nanoclay	-31.9

The FTIR investigation of nanoclays

FTIR analysis was carried out in order to locate the distinctive peak that was most evident in the nanoclay suspension. The results that were obtained are displayed in Fig. 4.2.2, which demonstrates that the various nanoclays (MMT K-10, MMT K-30, halloysite nanoclay, and bentonite nanoclays) each have their own distinctive prominent peaks, which can be seen at different frequencies as a result of the infrared radiations that are absorbed by the nanoclays. Because of the stretching vibration of OH groups on the MMT mineral, the FTIR spectrum of MMT K-10 and MMT K-30 nanoclays both revealed a high absorption peak about 3621 and 3633cm-1, respectively.

The XRD examination of nanoclays

The lattice shape and size of the particle were both determined through the use of XRD analysis. Measurements were taken of the XRD patterns of nanoclays in order to get insight into the d-spacing values, phase purity, and crystallinity of the particles. The XRD spectra of the four distinct nanoclays are displayed in Fig. 4.2.3, and the software OriginPro 9.0 was used to plot the spectrum that was acquired. The peaks with the highest intensity were selected, and then the 2-theta values were calculated. In addition, the d-spacing was determined by applying the equation developed by Bragg, which is presented in Table.

The data that were obtained were analyzed by contrasting them with the results of standard databases like the American mineralogist crystal structure database. The findings collected provided further evidence that the nanoclay in question was correctly identified. This is because every nanoclay exhibits a different combination of d-spacing values. For MMT K-10, MMT K-30, and bentonite nanoclay (all of which are of the centrosymmetric type), the crystal structure of all of the observed diffraction peaks indicates a monoclinic prismatic (C 2/m) crystal structure, but the crystal structure of halloysite nanoclay (of the polar type) is a monoclinic domatic m (cc) crystal structure. Every space group has a base in the center.

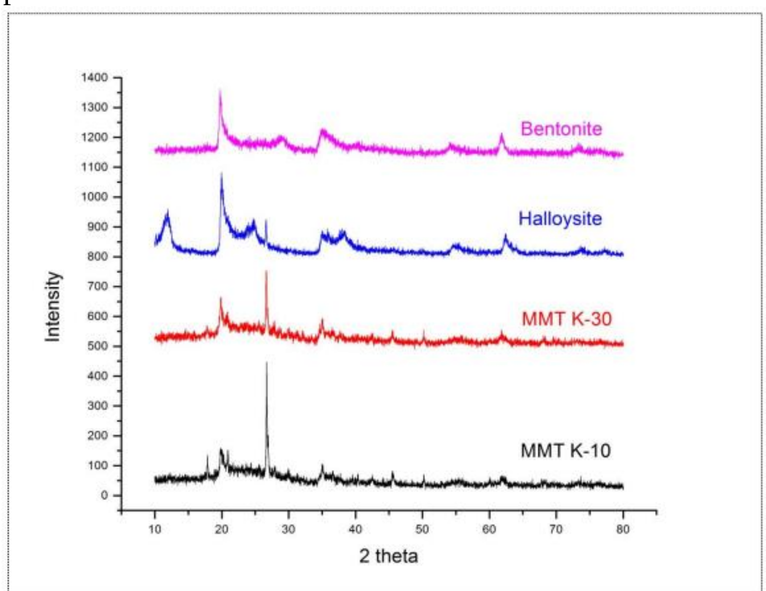

Figure 1: XRD spectra of each of the four unique nanoclays Halloysite nanoclay, bentonite nanoclay, MMT K-10, and MMT K-30, as well as MMT K-10.

Table2: Theta values obtained from XRD examination of four different nanoclays are represented here. The d-spacing was determined by using Bragg's equation to the data.

Nanoclay	2 theta value (Å)	d-spacing (Å)	Crystal structure
MMT K-10	5.83 19.2	15.1 4.6	monoclinic prismatic (C 2/m) (centrosymmetric)
MMT K-30	6.96 22.44 34.33	12.7 4.0 2.6	monoclinic prismatic (C 2/m) (centrosymmetric)
Halloysite Nanoclay	12.24 23.02 26.47 60.3	7.2 3.9 3.4 1.5	monoclinic domatic m (cc) (polar)
Bentonite Nanoclay	6.785 27.07 35.2 54.64 73.37	13.0 3.3 2.5 1.7 1.3	monoclinic prismatic (C 2/m) (centrosymmetric)

Nanoclays as shown by TEM micrograph

An examination using a transmission electron microscope was carried out in order to determine the morphology and size of the particles that were discovered in the four distinct nanoclays. Figure 4.2.4 displays a typical micrograph taken with a transmission electron microscope of nanoclays. In the current research, transmission electron micrographs (TEM) depicted MMT K-10 and MMT K-30 with a spherical morphology). Bentonite nanoclay had a spherical chain-like shape and had a particle size of around one hundred nanometers. In the nanoclays, the diameter of the particles ranged between 50 and 200 nm). The TEM picture of halloysite nanoclay is shown to have a hollow cylindrical the diameter of the particles in halloysite ranged from 50 to 100 nm.

DISCUSSION

The manufacture of MMT-based nanocomposites requires the screening of appropriate nanoclays.

Clay minerals that are environmentally benign are referred to as nanoclays. Nanoclays are nano-sized layered mineral silicates that have one dimension that is less than 100 nm. Nanoclays are widely acknowledged to be harmless and have the potential to be used as additives in food. In most cases, these minerals are non-toxic, and they are also biocompatible. They feature a higher cation exchange capacity, a decent swelling capability, and high aspect ratios. Additionally, they have a bigger surface area. As a result of these amazing capabilities, nanoclays have the potential to be exploited in the production of polymer-based nanocomposites in the role of the reinforcing nanofiller. The minerals montmorillonite, halloysite, kaolinite, bentonite, saponite, and laponite are all types of nanoclays.

The FTIR investigation of nanoclays

In most cases, FTIR spectroscopy is utilized as an analytical technique for the purpose of identifying the minerals. This identification is accomplished by comparing the FTIR spectra of the minerals to one another and locating the typical conspicuous peaks. As a result of the absorption of infrared light by the bonds that are present between two distinct elements, different peaks might be seen at various frequencies. The FTIR spectra of four different nanoclays all present prominent peaks in the region between 1025 and 1100 cm-1. These prominent peaks are specifically a characteristic of the Si-O bond stretching vibration of the nanoclay. The absorption peaks around 3400 and 3700 cm-1 were caused by the stretching vibration of the –OH group in all of the nanoclays. According to the research that has been done, the OH groups that are located on the inner surfaces of halloysite are most likely associated to the Al-centered octahedral sheets. These groups are essential in the formation of the hydrogen bonds that are formed with the oxygen sheet that is located in the double layer that is immediately after the one that contains halloysite. Very sharp bands have been seen in the lower section of the spectrum of bentonite nanoclay at 1424, 1104, 1032, 1009, 913, 797, 695, and 538 cm-1. These bands might be the result of stretching vibrations in the SiO4 tetrahedron. The results that were acquired from the FTIR study were compared to the standard IR spectrum, which validates the identification of the nanoclays that were purchased.

The XRD examination of nanoclays

The X-ray diffraction analysis is a strong technique that was utilized in order to determine the crystalline quality of any minerals and the d spacing that existed between various elements or various interlayers. In addition to this, it may assist in determining the geometry of the lattice, the size of the particles, and the purity of the phase. The XRD spectra may be acquired by directing the X-ray beam in the direction of the samples. This causes the materials to emit diffracted rays, which can then be detected. The values of 2theta were derived from the XRD patterns of nanoclays, and the d-spacing value was computed and compared with the standard database, which is the American mineralogist crystal structure database. The findings validated the identification of the acquired nanoclay after comparing it with the standard databases. Since each mineral has its own distinct set of d-spacing values, the comparison was necessary.

Nanoclays as shown by TEM micrograph

The particle shape of the nanoclays was determined with the use of TEM examination, and the particle size was also determined. TEM scans demonstrated that both MMT K-10 and MMT K-30, as well as bentonite nanoclay, had a spherical shape. According to the findings of previous research, MMT is a dioctahedral mineral that belongs to the smectite mineral group. It has a 2:1 interlayer linkage, which consists of two tetrahedral layers of silica sandwiching one octahedral layer of alumina. On the other hand, halloysite consists of a 1:1 interlayer linkage, which comprises the Al–OH groups (gibbsite The size of the halloysite employed was ranged in diameter from 50 to 100 nm, and the TEM picture of halloysite nanoclay indicated a hollow cylindrical shape. The findings of the TEM investigation showed that the diameter of the nanoclays ranged anywhere from 50 to 200 nanometers.

CONCLUSION

In the current investigation, the production of nanoclay-based nanocomposites was investigated using four distinct nanoclays: MMT K-10, MMT K-30, halloysite nanoclay, and bentonite nanoclay. Each of these nanoclays was put through a screening process. Initially, a variety of methods were utilized in order to determine the level of purity and distinctive qualities that they possessed. The following are the outcomes that may be obtained via characterization techniques:

Every particle in the nanoclays suspension has a zeta potential that is in the negative range, and they all have a high degree of physical stability. Particles that have a large negative zeta potential (less than -25 mV) typically have high degrees of colloidal stability. This is because the electrostatic repulsion between individual particles prevents flocculation of the particles.

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