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Sustainable Synthesis of Nano Fertilizer and Applications In The Field Of Agriculture.

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Abstract

For plants to absorb nutrients, fertilizers with specific chemical composition and higher analytical value are utilized. A fertilizer can contain any combination of nitrogen, phosphorous, potassium, and other necessary elements. The components must be easily accessible to plants, water-soluble, stable for long-term use, and affordable. It should also maintain the soil pH between 7 and 8 and be non-toxic to plants. Solids can exist in two forms amorphous and crystalline and are composed of tiny particles that aggregate to form larger granules. When these particles are smaller than 100 nm in size, they are referred to as nanomaterials. Nanomaterials have unique properties that differ from bulk materials due to their large surface area. They have been studied for their potential applications in fields such as agriculture ,catalysis, sensing devices, semiconductors, and medicines .

Nano-fertilizers are nanoscale materials, commonly in the form of nanoparticles, that contain macro and micronutrients and are delivered to crops in a regulated manner. Based on its formulation, nano-fertilizers are classified into three types: Nanoscale fertilizer is comparable to conventional fertilizer but smaller in size.Nanoparticles are often utilized. A nano supplemental fertilizer is a regular fertilizer that contains nanomaterials. Nanoscale coating fertilizer is nutrient-encased by nanofilms in nanoscale pores on a host material. Nanocomposite frameworks for controlling nutrition distribution have been created using nutrients enclosed by films or embedded in tiny holes inside a carrier material such as ceramics. A nanoscale regime product that distributes nourishment to crops.

Keyword: Plants; fertilizers; nutrients; nanomaterials; nanoscale.

Introduction

One important source of soil nutrients that promotes plant development and raises productivity is fertilizer. Farmers have been employing commercial fertilizers, which include a balanced distribution of the three primary basic minerals required for maximum plant growth: nitrogen, phosphorous, and potassium, [1]. The implementation of nanofertilizers in agriculture serves to minimize mineral wastage in fertilizing, raise yield throughout mineral management, and to improve growth in agriculture,[2].

Phosphorus deficits is an ongoing issue limiting yield and crop quality throughout the world, so

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ensuring adequate agricultural output will mostly require increased demand for fertilizers containing phosphates, since phosphorus is a vital component for plant development and growth ,[3]. calcium phosphates the most abundant inorganic element found in living tough tissues like bones, the dentine, and deer horns.The impulsive production of these biominerals has been used as a source of motivation for the development of advanced nanomaterials with improved performance and new applications,[3].

N is needed floral growth and progress and is a important of photosynthesis. Furthermore, it is a important part of amino acids, which serve as foundation for enzymes and proteins in plants. Enzymes and proteins, which are the building blocks of all living things, control the biochemical processes of plants to produce the highest possible crop output. Fertilizer firms confront several obstacles in increasing the efficacy of their products, since appropriately utilizing These resources must be used intelligently in order to increase agricultural yield and minimize costs. Loss of nutrients to the environment. This is possible.by improving items that are already in use or being manufactured fertilizers which are novel,[4]Farmers in poor countries, especially in Southeast Asia, primarily feed their crops with nitrogen and, to a lesser extent, phosphorus, and little to no potash. Unbalanced fertilizer use leads to poor fertilization effectiveness and is extremely worrying for environmental degradation, especially for N and P. Delayed or regulated release fertilizer are being shown to have improved nutrient utilization efficiency because of their focused and timely delivery of nutrients.,[5],[6].

Methods and materials

Top down approach

The Top-down synthesis process may be represented as the process of dispersing large-size materials into small-size particles with a range of nm sizes within a predefined form or morphology. Collection of mineral or precious resources, as well as molecules from agro-based applications, would add value to the output in terms of economic benefit.

Rice straw is a low-cost plentiful agricultural commodity that causes pollution when burnt. The lignin and silica oxide are extracted from the straw using the acid-base hydrolytic technique.The three primary components of agro-waste are cellulose, hemicelluloses, and lignin, which are destructed into smaller carbon compounds via biobiochemical conversion processes.,[8],[9].

Hydrothermal method

Hydrothermal processes takes place in a closed vessel with raised heat treatment at autogenous pressure throughout differed time periods. The zeolites possess multiple distinct properties, like, Composition of the blends (silica to alumina proportion; OH-; inorganic ions; carrier inert substances) Reactants nature and pretreatment procedures,Heating conditions within the process Synthesis holding period ,The reaction mixtur's the pH level

Microwave synthesis

When compared to conventional thermal technology, microwave approaches are appealing owing to selective and internal heating, uniform volumetric heating, indirect interaction with the heating source, and periodic process control. The precise electromagnetic radiation falling between 300 MHz and 300 GHz, up to 2.45 GHz, which is comparable to 122 mm in wavelength and 1.02x10-5 eV in energy. Microwave radiation on a dielectric substance may produce polarized by dispersing intrinsic bond charges. In this case, microwave penetration through radiation frequency, physical structure, and chemical bonding show adsorption capabilities on the materials. The materials' absorbability determines whether microwave adsorption rises

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with temperature or whether additional external heating sources are necessary,[9].

Ultrasonication method

The synthesis of a variety of nano and microparticles has been achieved by the effective application of ultrasound in conjunction with the sol-gel technique. The primary mechanism that improves crystallization using an efficient ultrasonic cavitation approach. Bubbling promote secondary nucleation and mass transfer, leading to higher crystal growth rates. As a result, the time and temperature needed for the synthesis of micro and nanoparticles may be greatly decreased by using ultrasonic. According to certain research, the sonication technique increases the level of crystallized substance.

Metal inclusion

Plants may manufacture fertilizers in the shape of metal ions during photosynthesis, which may absorb soluble salts for their physiological mechanism . Metallic nanoparticles are also introduced into plants via chemical fertilizers, pesticides, and herbicide .

The nanoparticle delivery system consists of the transfer of molecules of DNA or nucleotide into cells of plants. Using agricultural chemicals for trapping, weak ionic bond attachment, digestion, and capsulation is another technique for integration . Bio-nanotechnology also provides tools for changing genes in plants to produce nanoparticles on their own behalf.

Using techniques like acid-base hydrolysis, the top-down synthesis strategy breaks down big materials into tiny particles. This process is used for removing lignin and silica oxide from rice straw. To manufacture zeolites with specified characteristics, the hydrothermal process is used in an enclosed chamber with increased heat treatment. By using microwave radiation to cause polarization in dielectric materials, microwave synthesis provides benefits including uniform volumetric heating and selective heating. When used in conjunction with the sol-gel process, ultrasonication promotes the secondary nucleation and mass transfer, lowering synthesis time as well as temperature for nano and microparticles. Metal inclusion in plants happens by the absorption of metallic nanoparticles from fertilizers, insecticides, and herbicides, with bio-nanotechnology providing instruments for genetic alteration

Benefit of nano fertilizer to the plant bodies

1. Nitrogen Resource to feed Crop Growth: Nano Urea (Liquid) is a source of nitrogen that must be used for optimum plant growth and development,[10].
2. Nitrogen's Role in Amino Acids: Nitrogen is an essential component of amino acids, facilitating plant protein synthesis. This nitrogen is found in nano urea.
3. Enzyme Support: Nano Urea promotes the synthesis of enzymes, which are required for a variety of biochemical processes in plants.
4. Support for Genetic Material: The chemical makeup of genetic materials is influenced by nitrogen from nano urea, which in turn affects plant characteristics and genetics. The generation of photosynthetic pigments, which are necessary for the plant to produce energy through photosynthesis, is facilitated by Nano Urea.
5. Energy Transfer molecules: The element nitrogen in Nano Urea helps plants produce energy transfer molecules.
6. Enhanced Nutrient Uptake: Plants that receive nano fertilizers are able to absorb nutrients more efficiently. The tiny particle size enhances the amount of surface area accessible for contact with plant roots, enhancing the absorption of nutrients such as nitrogen, phosphate, and potassium.

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7. Controlled Nutrient Release: It is possible to create nano fertilizers with controlled release of nutrients characteristics. This ensures a consistent and constant discharge of minerals over time, giving plants with greater stability and longer nutrient supply, this can be particularly beneficial in locations with fluctuating nutrient availability,(10).
8. Enhanced Nutrient Utilization: The all-around nutrient utilization efficiency of plants can be improved using nano fertilizers. They improve crop fertilizer consumption by supplying nutrients in a focused and effective way, reducing losses due to leaching or volatilization.
9. Decreased Ecological Effect: The controlled-release characteristic of nano nutrients may reduce the ecological consequences linked to traditional fertilizers. This involves reducing the discharge of nutrients into body water and the danger of water and soil contamination.
10. Diseases Tolerance: Research has been done on the potential of several nano fertilizers to strengthen plant immunity to illnesses. They could boost the plant's resistance to diseases by activating its defensive systems.
11. Stress Conditions Adaptation: Plants can be made more resilient to environmental stressors including salinity and heavy metal toxicity with the use of nano fertilizers. They have the potential to alleviate the harmful impacts of stress, enabling crops to survive under challenging conditions [11].

Results and discussion

The implementation of nano Fertilizer in plant farming is projected to produce good outcomes in a variety of criteria. Because of their nano size, nano-fertilizers are expected to dramatically enhance nutrient uptake and absorption efficiency for vital components. Their controlled-release features are expected to provide a uniform nitrogen delivery while addressing soil variability and mitigating possible adverse effects related to traditional fertilizers,[12]. In addition, several nano Fertilizer are projected to boost soil water retention, providing a twofold advantage for agricultural production in regions with frequent droughts. The effective administration of micronutrients is anticipated to help address critical deficits for plant health. It is established that biological stimulant effects would be noticed, suggesting the potential for not just nutrient supply but also increased development and growth in plants.

Furthermore, nano-fertilizers are projected to demonstrate promise in improving disease resistance and assisting crops in adapting to adverse conditions,[13], indicating their potential in combined pest control and resistance in difficult situations. Nano Fertilizer' precision farming potential, which allows for precise nutrient control, is anticipated to correlate with environmental agricultural techniques. Although these projections are encouraging, determining possible limits and highlighting the importance of more study on scaling, financial viability, and possible risks will be critical in the future for reaping the full benefits of nano-fertilizers in a variety of agricultural circumstances,[14].

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Conclusion

In general, the synthesis and use of nano-fertilizers offer a viable path forward for sustainable agriculture by tackling issues with crop resilience,[15], environmental impact, and

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nutrient efficiency. Top-down synthesis methods, such as acid and base hydrolysis and hydrothermal procedures, show effective means of recovering beneficial elements from agricultural waste, including as rice straw. Furthermore, methods like the use of microwaves and ultrasound treatment help to the development of nanoparticles that have particular agricultural features. Nano-fertilizer uses include more effectively distribution of nutrients, controlled release, improved nutrient usage productivity, and adaptability under stress situations. These advantages have the potential to significantly improve methods for agriculture, particularly in regions with nutrient deficits and pressures from the environment.

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