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ROLE OF NANOTECHNOLOGY IN HORTICULTURE

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The development of nanotechnology creates an excellent opportunity to address complex technical issues in the food supply chain. Failure to embrace nanotechnology will deny the horticultural sector an opportunity to capitalize on improved product visibility, food safety, quality and security, and associated economic benefits. Agricultural and food supply chain management is complex due to the diverse characteristics of agricultural products. There are numerous types of horticultural crops and products, many of which are perishable. In addition, the degree of standardization of some kinds of fruit products and their management is still low. In this regard, the potential application of nanotechnology to horticulture is reviewed. Investigation confirms that in credential application of nanotechnology in horticulture, first in fruit packaging and later in other areas such as tracking, tracing, storage, and distribution, is occurring. Currently, most nanotechnology applications in the agricultural supply chain are concentrated in packaging, mainly in the improvement of packaging materials for product security, quality, and safety. From the point of view of the supply chain, the logical extension is the application of intelligent packaging based on nano-sensors with a view to promoting information and management across all elements of an agricultural supply chain. Compared with traditional sensors and their shortcomings, nano-sensors have several advantageous properties, such as high sensitivity and selectivity, near real-time detection, low cost, and portability. However, the economics of nanotechnology application in the agricultural supply chain is no more different from the application of other new technologies.

- Agriculture has always been the backbone of most of the developing countries.

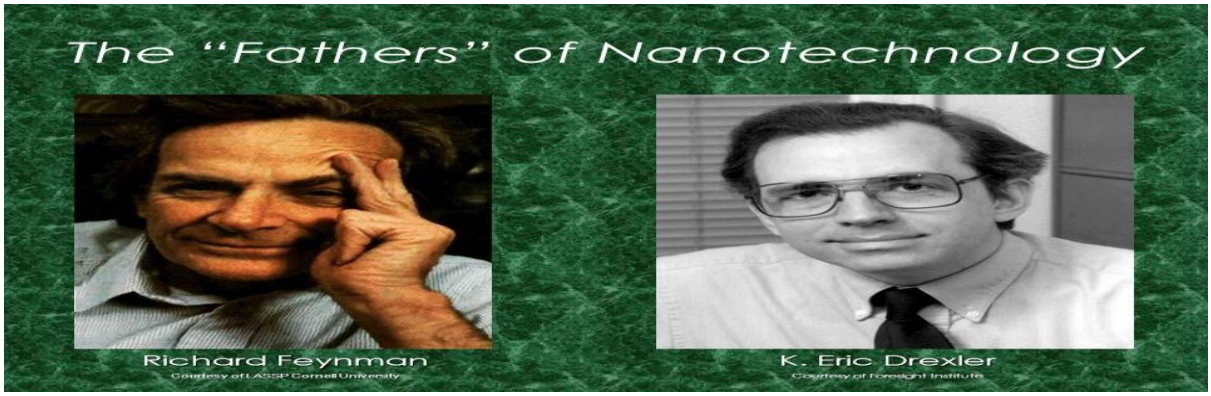
- In recent decades the agricultural scenario has witnessed several challenges like burgeoning population, shrinking farm land, depletion of natural resources, resurgence of new pests and diseases and global warming.
- With increasing population there is further pressure on this sector to meet the growing food demand.
- To address all these challenges, there is a need for an alternate technology such as nanotechnology that promotes productivity while ensuring environmental safety.

Current Scenario of Nanotechnology in India

- ✓ Apart from raising crop yield, it may also help the country cut import of urea, estimated to be about 9 million tonnes in 2019-20.
- ✓ Farmers use 30-32 million tone of urea per year to grow their crops. E.g- For instance, if farmers are using 2 bags of urea in 1 acre, instead of this they may use 1 bag and 1 bottle of nano urea. By this cost reduced.

History

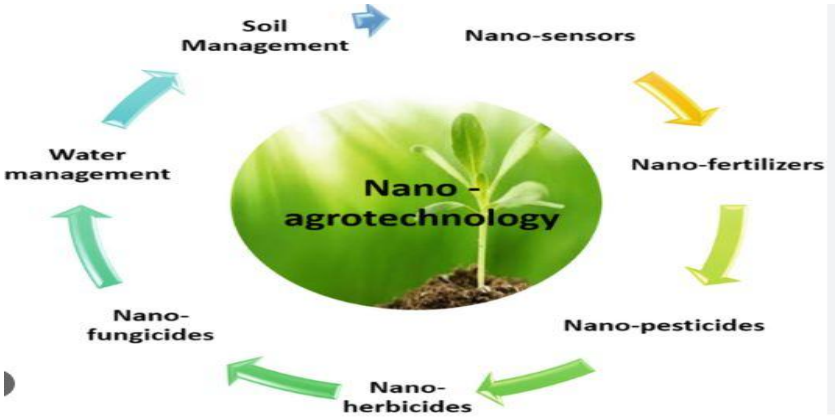
- 2000 Years Ago - Sulfide nano crystals used by Greeks and Romans to dye hair.
- 1000 Years Ago - Gold nano particles of different sizes used to produce different colors in stained glass windows.
- 1959 - The first concept discussed by renowned physicist Richard Feynman in his talk There's Plenty of Room at the Bottom.
- 1974 -,, Nanotechnology" - Norio Taniguchi uses the term nanotechnology for the first time.
- 1981 - IBM develops Scanning Tunneling Microscope.
- 1985 -Bucky ball" - Scientists at Rice university and University of Sussex discover C60.
- 1986 - K. Eric Drexler independently used the term "nanotechnology" in his 1986 book Engines of Creation: The Coming Era of Nanotechnology.
- 1991 - Carbon nanotube discovered by SumioLijima.
- Richard Feynman Tiny Machines, BUCKY BALL" The Feynmean Lecture on Nanotechnology 10,10 nanotube.



List of Nano Organizations in India

- Centre for Nanoscience and Nanotechnology, JMI, New Delhi.
- International Institute for Nanotechnology (IIN) was established by Northwestern University in 2000, United states.
- Center for Nano Technology, UAS Raichur.
- Department of Nano Science and Technology (TNAU), Coimbatore.
- Department of Nanotechnology (University of Kashmir).
- Indian Association for the Cultivation of Science (IACS)
- Centre for nano science and technology, Pondicherry university

Scope of Nanoparticles in Agriculture As Well As In Productivity and Quality of Horticultural Crops



What is Nanotechnology?

- Nanotechnology is a field of research and innovation concerned with building 'things' – generally, materials and devices – on the scale of atoms and molecules.
- Attempts to apply nanotechnology in agriculture began with the growing realization that conventional farming technologies would neither be able to increase productivity

any further or restore ecosystems damaged by existing technologies back to their pristine.

- Nanotechnology is emerging as the sixth revolutionary technology in the current era.
- Nanotechnology interventions for vegetable production and protection can assure improved productivity with low inputs, enhanced input use efficiency, precision application through quick diagnosis of the pest/pathogen attack and by curbing non-target losses that may lead to environmental contamination and hazards (Kalia & Sharma, 2019).
- Nano particles is defined as the small object that acts as a whole unit in terms of transport and properties. (Natural or synthetic particle)
- Nano particles are characterized by unique physical and chemical feature like surface area, pore size, particle morphology and reactivity.
- Another name of NPs is "magic bullet" due to their intensive application in agricultural field.
- Nano particles can be used as nano-fertilizer, nano-pesticide and herbicides which are useful to increase crop productivity, to control excessive use of chemical fertilizer and also increase survivability against biotic stress.

Quantification of Nano Particals

- Nanotechnology is the study and control of phenomena and materials at length scale 1 to 100 nm.
- 1 nm = 10-9 m or 1 billionth of a meter.
- 1/50,00,000 the size of an ant.
- 1/80,000 of the diameter of a human hair.
- 1/90th size of HIV virus.
- 1/10 diameter of hydrogen atom Nano particles of various shapes and forms Uniform/irregular shape. Dispersed particles/agglomerates.

Tools of Nano Technology

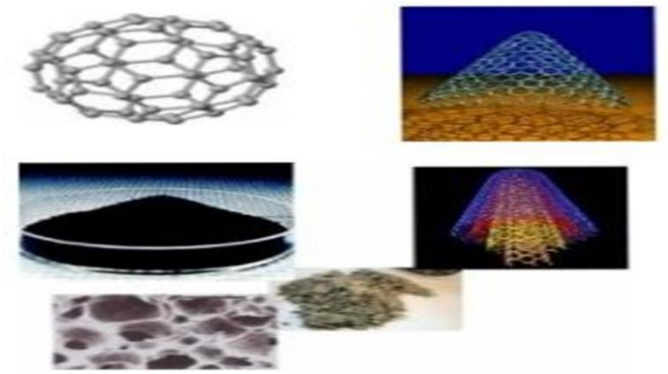
Why Nano Technology?

- High surface area and high reactivity
- Effective catalyst of plant/microbial metabolism
- Better penetration into the cell
- Increased both plant and microbial.
- Nano materials can be either:

a) Natural: Materials having one or more dimensions in the nano scale. e.g., Soil colloids
b) Incidental: Materials formed as a result of man-made or natural processes. e.g., Welding, milling, grinding or combustion.

Nanocarbon

- Fullerene
- Tubes
- Cones
- Carbon block
- Horns
- Rods
- Foams
- Nano diamonds



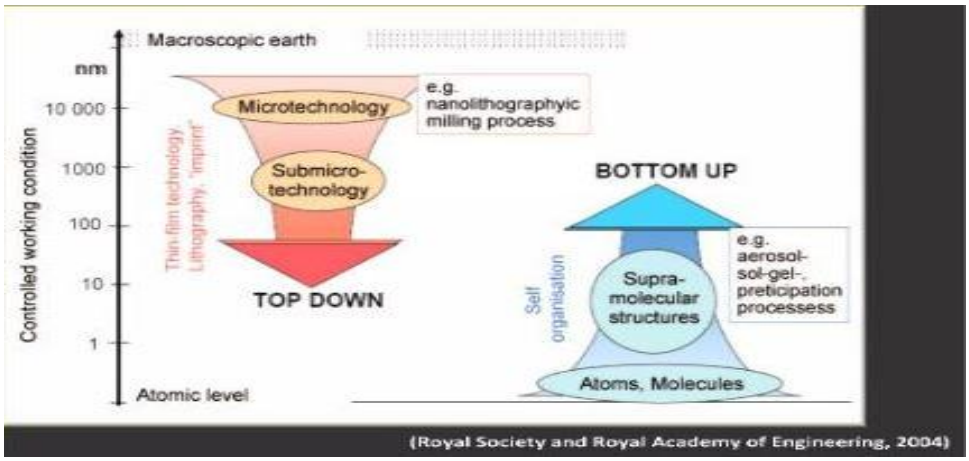
Advantages of Nano Technology

- Increase Productivity – Nano technology helps to improve horticultural production by increasing the efficiency of inputs and minimizing relevant losses.
- Improve soil quality – Nano fertilizers are used to increase vegetative growth, Pollination and fertility of flowers, resulting in increased yield and improved product quality for fruit trees.
- Provide smart monitoring – Nano sensors facilitate up to date monitoring of growth, plant disease, and pest attack in crop plants under field conditions.
- Plant protection and disease scouting – Nano sensors used to measure toxicity, nutrient deficiency, Pest attack.
- Minimal tillage practices.
- Nano filtration – reduce impurity.
- Weed management – slow-release complex.

Limitations of Nano Technology

- Whole plant can obviously be used to produce metal nano particles, however there exist some limitations.
- The heterogeneity of the size and morphology of nano particles produced in whole plant may hinder their use in application where specific, finely tuned sizes and shapes are required; illustrating the inability to tailor the whole plant synthesized nano particles to market requirement.
- Moreover, efficient extraction, isolation and purification of nano particles from plant materials is a difficult and problematic procedure, with a low recovery.

Methods of Nanoparticals Production



Preparation of Nanoparticles

- ❖ Sol-gel synthesis
- ❖ Colloidal precipitation
- ❖ Co-precipitation
- ❖ Combustion technique
- ❖ Hydrothermal technique
- ❖ High energy ball milling
- ❖ Sono chemistry

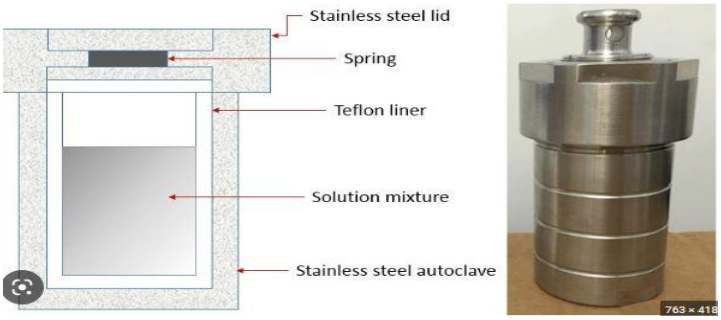
Sol –Gel Synthesis

- Wet chemical technique
- Chemical solution deposition

- For gel like properties particle density should be increased by removing significant amount of solvent.

Hydro Thermal Technique

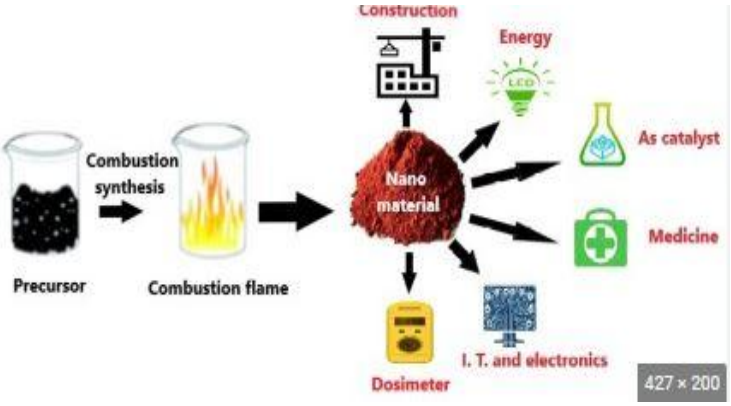
- Conducted in steel pressure vessels called auto claves with or without Teflon liners.
- Under controlled temperature and/or pressure with their action in aqueous solution.



- Widely used for the production of small particles in ceramics industry.
- Used to prepare nano particles of Ti02.

Combustion Technique

- Used for the preparation of nano particle sized LiBi02.
- Requirements
- Lithium Nitrate
- Bismuth Nitrate
- Urea(igniter-fuel)
- Glycerol(binding material)



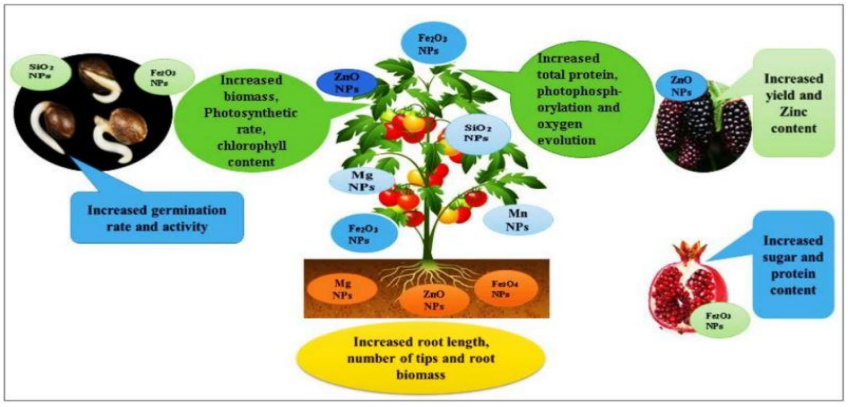
Synthesis of Nano Particles

The nano particles may be synthesized by physical, chemical, biological and aerosol technique. Physical synthesis method includes sedimentation process, rotor speed mill, high energy ball mill and pot mill. In general, phosphorus (P) nanoparticles are prepared by purifying rock phosphate and grinding with high energy ball mill or pot mill.

Crop Growth

- Nano materials have the potential to penetrate the seed coat and enhance the ability of absorption and utilization of water, which improves germination and seedling growth Nano materials, such as ZnO2, TIO2, FeO2, Zn, Fe, Cu-oxide and hydroxyl fullerenes

are reported to increase crop growth and development with quality enhancement in many crop species including, onion, spinach, tomato and potato.



- The growth and development is increased due to long term availability of nutrients to the plant over the full crop period of cultivation is crucial for promoting germination, growth, flowering and fruiting.

Application of Nanotechnology in Vegetable Crops

- ✓ Nanotechnology helps to revolutionize horticulture and food industry. Nano materials commonly used in vegetables include silver nano particles, zinc oxide nano particles, titanium dioxide nano particles. The benefits of nanotechnology in vegetable production are enormous.
- ✓ These include control of insect pests using nano pesticides and nano insecticides, increase in vegetable production and productivity using nano particles encapsulated fertilizers and bio fertilizers.

Frontline of Nano Technology in India


In the presence of the Union Minister of Chemicals & Fertilizers and Health & Family Welfare Mansukh Mandaviya, a practical field trial of drone spraying of Nano Liquid Urea was conducted by IFFCO in Bhavnagar, Gujarat, on October 1. India has become the first country in the world to start commercial production of Nano Urea.

Chemicals Used in Nano Technology

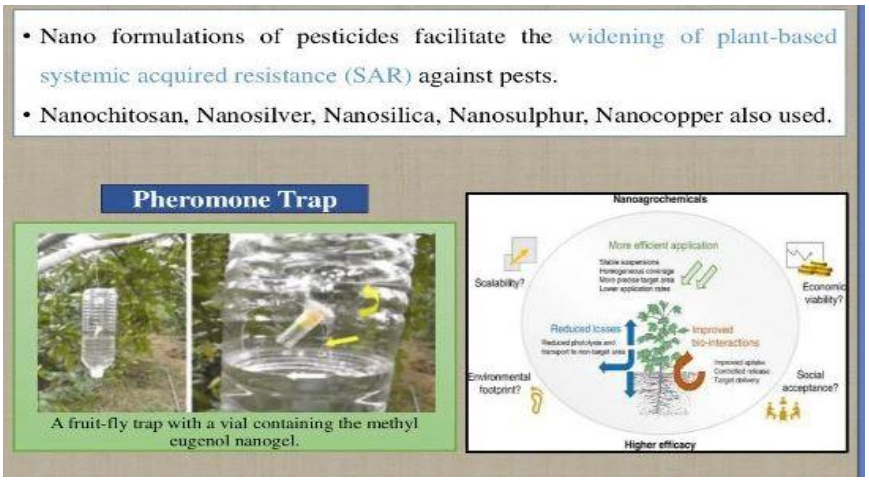
- All of the chemicals used in the study were at their highest integrity.
- Calcium hydroxide ($Ca(OH)_2$)
- Orthophosphoric acid (H_3PO_4)
- sodium hydroxide (NaOH)
- Trisodium citrate ($Na_3C_6H_5O_7$)
- Urea molecules ($CO(NH_2)_2$)
- Other chemicals including zinc chloride ($ZnCl_2$), copper chloride ($CuCl_2$), and ferrous chloride ($FeCl_2$)

Nano Fertilizer Products

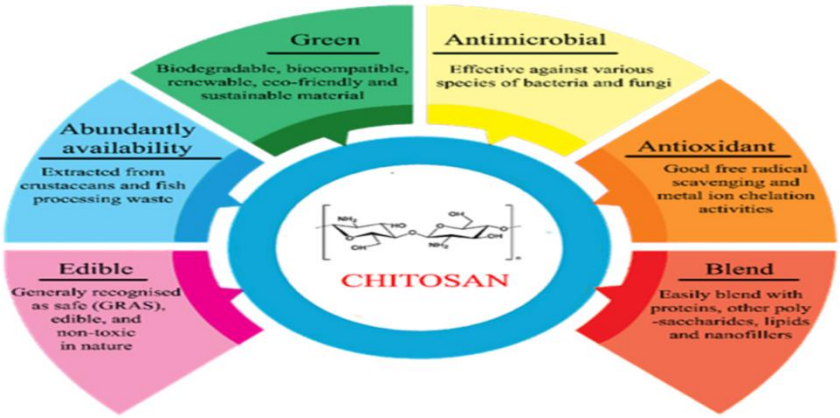
Plant Protection

- Among the applied pesticides, much amount lost in the environment or unable to reach the target sites. This not only increases the expenses of crop.

- Production, but also causes the depletion of environmental systems. Nano formulation of pesticide facilitate the persistence or controlled release of active ingredients in root zones or inside plants without compromising effectiveness. Conventional formulations having limited water solubility of pesticides.
- Also injure other organisms, leading to increased resistance to target organisms. More importantly, the timely and controlled release of active ingredients.



Nano Chitosan



Nano Partlcles in Post-Harvest Disease Management

- Different nano materials showed important potential in post- harvest. Technology management by controlling growth and development of microorganisms.
- Several investigations support that Nano-packing material had quite beneficial effects on physicochemical and physiological quality compared with normal packing material.

- Therefore, the Nano-packing may provide an attractive alternative to improve the preservation qualities of fruits, vegetables and other valuable horticultural crops during extended storage.

Comparison of Packing with Nano Packing and Conventional Packing and Their Effect on Reduction in Decay Rate, Anthocyanin and Malondialdehyde Contents

Nanotechnology has the potential to generate new fruit packaging. The new technology of nano-packing materials with lower relative humidity, oxygen transmission rate, and high strength was synthesized by blending polyethylene with nano-powder (nano-Ag, kaolin, anatase TiO2, mineral TiO2), and it enhanced the preservation quality of fruits throughout storage at 40°C.

Concluding Remarks and Prospects of Nano Technology

- ❖ Nanotechnology is advancing as a state-of-the-art tool in modern agriculture to facilitate sustainable crop production.
- ❖ It also has a great promise in horticulture, where different kinds of nano materials are used to increase productivity and quality of produce and reduce post-harvest spoilage of fruit and vegetables.
- ❖ Nanotechnology takes advantage of the power of nano materials and their distribution methods for improvement of the productivity of horticultural crops. They reduce the over-use of chemical fertilizer and pesticides. Nano materials are simple, cost-effective, and eco-friendly, allowing them to be produced in a minimum time and with less effort and without causing any harm to the environment.

Future Prospects

- ✓ "More studies are needed to explore the mode of action of NPs, their Interaction with bio molecules, and their impact on the regulation or gene expressions In plants.
- ✓ "Research on nano particles with respect to crop protections should be geared towards introduction of faster and ecofriendly nano formulations in future**.**

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