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NANOTECHNOLOGY: AN EMERGING APPROACH IN AGRICULTURE

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Abstract:

Agriculture is always most important and stable sector because it produces and provides raw materials for food and feed industries. Because of the growing global population, increased nutrient mining, need to increase the total food grain production, shrinking arable lands, limited water availability, declining soil organic matter, climate change and so many other reasons; modern agricultural technologies such as nanotechnology. Nanotechnology has numerous applications in all stages of production, processing, storage, packaging and transportation of agricultural products. In agriculture, nanoparticles aim to reduce the amount of chemicals spread, minimize nutrient losses in fertilization and increased yield through pest and nutrient management. The significant interests of using nanotechnology in agriculture includes specific applications like nano-fertilizers and nano-pesticides to trail products and nutrients levels to increase the productivity without decontamination of soil, water and protection against several insect pest and microbial diseases. Nanotechnology could be used as sensors for monitor soil quality in agricultural field and helping to keep agricultural plants healthy. Precision farming techniques, enhancing the ability of plants to absorb nutrients, more efficient and targeted use of inputs, disease detection and control diseases, withstand environmental pressures and effective systems for processing, storage and packaging systems are all examples of how nanotechnology will revolutionize agriculture and food industry. With the help of nano clays and zeolites increase the efficiency of applied fertilizer and restore soil fertility by releasing fixed nutrients. Nanoherbicides are being developed to solve perennial weed management issues and a rapidly depleting weed bank. Nano smart dust and gas sensors can swiftly assess pollution levels in environment.

About Nanotechnology:

Nanotechnology is a group of emerging technologies in which the structure of the matter is controlled at the nanometer scale to produce materials having unique properties. In other words, nanotechnology is the manipulation or self-assembly of individual atoms, molecules, or molecular clusters into structures to create materials and devices with new or vastly different properties.

Nanoparticles (NPs):

- ❖ Nanoparticles is defined as the small object that acts as a whole unit in terms of transport and properties. The word 'nano' is used to refer to 10^{-9} or a billionth part of one meter. It is generally used for materials of size between 1 nm to 100 nm.

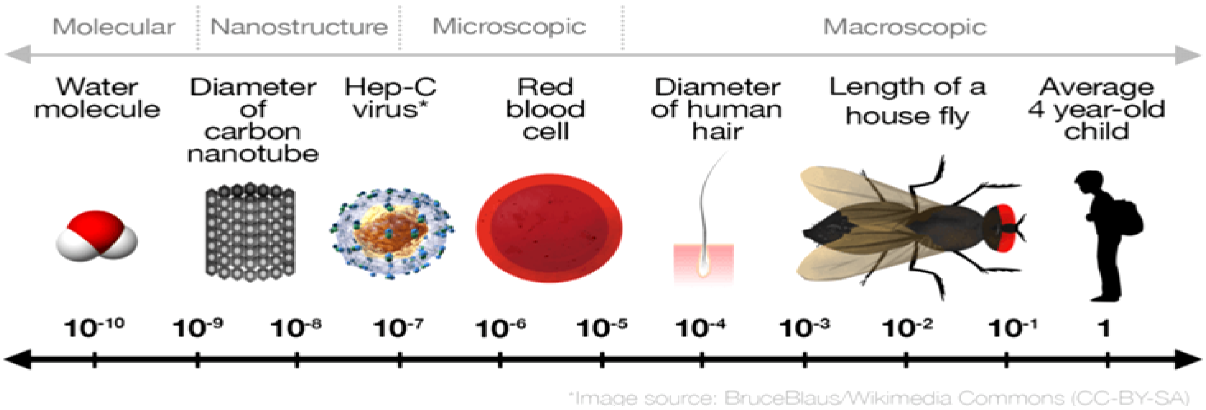
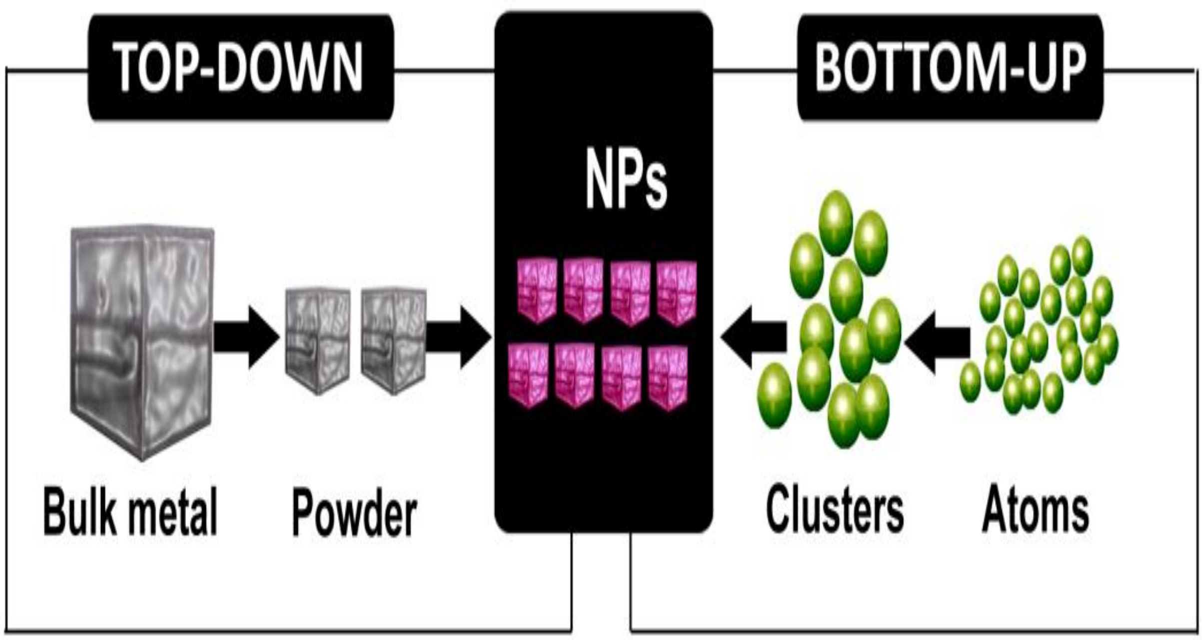


Figure 1 Scale of nanoparticles

Approaches in nanotechnology:

1. **Top-down Approach:** In this approach creating nano-scale materials by physically or chemically breaking down larger materials
2. **Bottom-up Approach:** In this approach assembling nano materials atom-by-atom or molecule-by-molecule (self assembling)



Nanotechnology in agriculture

- Nanotechnology in precision farming
- Nanotechnology in tillage
- Nanotechnology in seed sciences
- Nanotechnology in water use
- Nanotechnology in fertilizers
- Nanotechnology in plant protection
- Nanotechnology in weed management

Nanotechnology in precision farming:

Precision farming has been a long-desired goal to maximize output (i.e. crop yields) while minimizing input (i.e. fertilizers, pesticides, herbicides etc.) through monitoring environmental variables and applying targeted action. Precision farming makes use of computers, global satellite positioning systems, and remote sensing devices to measure highly localized environmental conditions thus determining whether crops are growing at maximum efficiency or precisely identifying the nature and location of problems. By using centralized data to determine soil conditions and plant development, seeding, fertilizer, chemical and water use can be fine-tuned to lower production costs and potentially increase production- all benefiting the farmer. Precision farming can also help to reduce agricultural waste and thus keep environmental pollution to a minimum.

Nanotechnology in tillage:

Use of nano-materials improve soil structure and reduce mobility, availability and toxicity of heavy metals. Nanotechnology improve soil quality by increasing water holding capacity and nutrient availability.

Nanotechnology in seed science:

In India, more than 60% of the net area sown is under rainfed system, it is quite appropriate to develop technologies for rainfed agriculture. A group of research worker is currently working on metal oxide nano-particles and carbon nanotube to improve the germination of rainfed crops. Their data have shown that carbon nanotubes (CNTs) serve as new pores for water permeation by penetration of seed coat and act as a gate to channelize the water from the substrate in to the seeds. These processes facilitate germination which can be exploited in rainfed agriculture system.

Nanotechnology in water use:

Nano-sensors such as based on titanium oxide nanowires are used in analytical detection of contaminants in water samples. Toxic trace elements such as arsenic can also be removed using nanotechnology.

Nanotechnology in fertilizers:

In the recent decade nano-fertilizers are freely available in the market, but particularly the agricultural fertilizers are still not shaped by the major chemical companies. Nano-fertilizers may contain nano zinc, silica, iron and titanium dioxide, gold nanorods, core shell etc. as well as should endorse control release and improve its quality. Studies of the uptake, biological fate and toxicity of several metal oxide NPs, *viz*., AlO, TiO, CeO, FeO and ZnO NPs were carried out intensively in the present decade for agricultural production (Zhang *et al*., 2016). Molecular modified or synthesized materials with the help of nanotechnology, used to improve the fertility of soil for a better crop yield and quality.

Nanotechnology in plant protection:

Traditional pest control involves the use large quantities of pesticides, resulting in environmental pollution and additional cost of production. Dilution of the pesticides with the nano-treated water could greatly improve their efficiency. This could also reduce the quantity of chemicals used. Nano-pesticides are three fold more efficient than the conventional pesticides in controlling pests. It also reduces the cost by half of the conventional pesticides.

Nanotechnology in weed management:

Multi-species approach with single herbicide in the cropped environment resulted in poor control and herbicide resistance. Continuous exposure of plant community having mild susceptibility to herbicide in one season and different herbicide in other season develops resistance in due course and become uncontrollable through chemicals. Developing a target specific herbicide molecule encapsulated with nanoparticles is aimed at specific receptor in the roots of target weeds, which enter into roots system and translocated to parts that inhibit glycolysis of food reserve in the root system. This will make the specific weed plant to starve for food and gets killed. In rain fed areas, application of herbicides with insufficient soil moisture may lead to loss as vapour. Still we are unable to predict the rainfall very preciously; herbicides cannot be applied in advance anticipating rainfall. The controlled release of encapsulated herbicides is expected to take care of the competing weeds with crops. Adjuvants for herbicide application are currently available that claim to include nanomaterials. One nanosurfactant based on soybean micelles has been reported to make glyphosate-resistant crops susceptible to glyphosate when it is applied with the 'nanotechnology-derived surfactant'.

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