

Nanotechnology in Sustainable Agriculture

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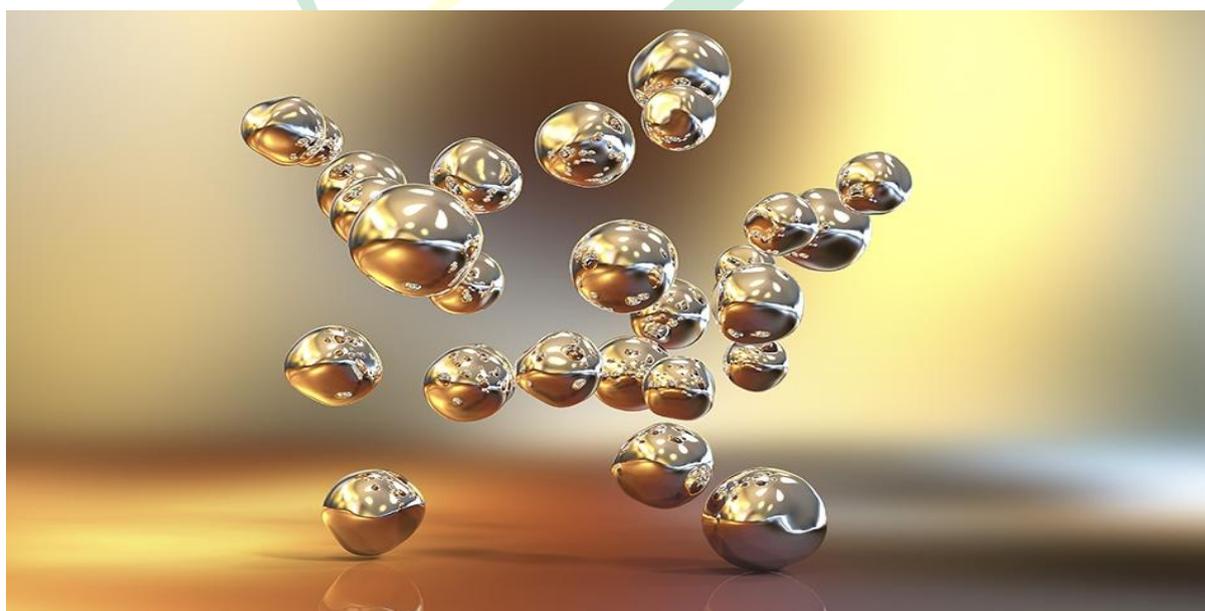
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Introduction

Nanotechnology has gained a massive response in past few years due to its wide applications in several areas like medicine, medicinal drugs, catalysis, energy and material. Nanoparticles with small size and large surface area (1-100nm) have potential industrial, medical and agricultural operations.

A recent report by the United Nations projected that the global population would become 8.5 billion by 2030 and approximately 9 billion by 2050. It is the need of the hour to fulfil the nutritional demands of the rapidly growing population. In this regard, nanotechnology has contributed to the agrotechnological revolution that has immense potential to reform the resilient agricultural system while promising food security. Therefore, nanoparticles are becoming a new-age material to transform modern agricultural practices. The variety of nanoparticle-based formulations, including nano-sized pesticides, herbicides, fungicides, fertilizers, and sensors, have been widely investigated for plant health management and soil improvement.

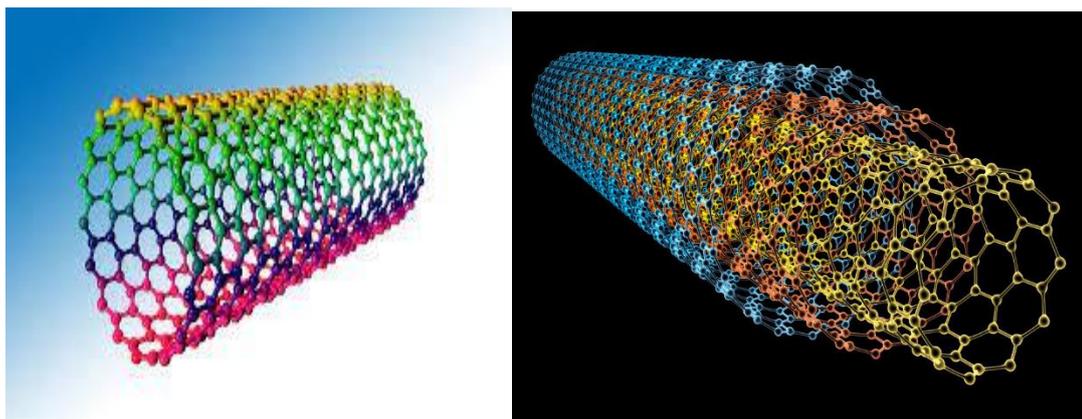


Nanotechnology could be simply defined as the design and production of structures, devices and systems by controlling shape and size at nanometer scale. (Nutraceuticals, 2016) Nanotechnology is the term given to those areas of science and engineering where phenomena that take place at dimensions in the nanometer scale are utilised in the design, characteristics, production and application of materials, structure, devices and systems. (European Commission - EUROPA). Agriculture plays an essential role in sustaining and driving the economy. It is the backbone of everything that drives us. In addition to providing food and other raw materials, it also provides employment opportunities. No doubt that the sustainable growth of agriculture totally depends on the new and innovative techniques like nanotechnology. Naturally, it haunts us to know what is this important technology? If we like to go in the year 1959 Feynman's lecture on "Plenty of room at the bottom," from this very day, the nano process is in underway (Feynman, 1996).

Various Nanoparticles and Their Functions

- **Nanoemulsions:**-Nanoemulsions are a colloidal particulate system in the submicron size range acting as carriers of drug molecules. Their size varies from 10 to 1,000 nm. As a drug delivery system they enhance the therapeutic efficacy of the drug and minimize adverse effect and toxic reactions. Major application includes treatment of infection of the reticuloendothelial system (RES), enzyme replacement therapy in the liver, treatment of cancer, and vaccination. They are non toxic and non irritant in nature and improves physical stability.
- **Nanoencapsulation:**-Encapsulation is defined as process in which the given object is surrounded by a coating or embedded in homogeneous or heterogeneous matrix. Nanocapsules are vesicular systems in which the substances are confined to a cavity consisting of an inner liquid core enclosed by a polymeric membrane (Couvreur et al.,1995). One of the most attractive advantages associated with nanoencapsulation is attributed to its ability to protect active pharmaceutical ingredients (API) from degradation. Nanoencapsulation has also improved the precision of drug delivery targets by utilizing surface coating or conjugating that ensures adequate cell entry.
- **Carbon Nanotubes:**-Carbon nanotubes are cylindrical large molecules consisting of a hexagonal arrangement of hybridised carbon atoms, which may be formed by rolling up of a single sheet of graphene (single walled carbon nanotubes SWCNTs) or by rolling

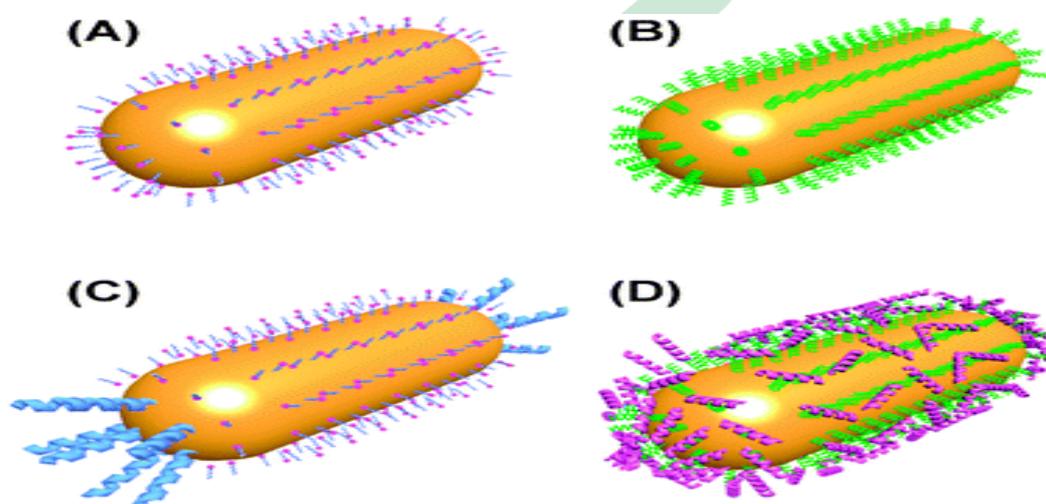
up multiple sheets of graphene (multiwalled carbon nanotubes, MWCNTs) (From - Surface chemistry of nanobiomaterial, 2016). Exploitation of the properties of CNTs definitely will open new possibilities to develop many types of nanodevices which confers unique conductive, optical and thermal properties for applications in agri-field and in development of sustainable agricultural conditions.



Single Walled CNTs

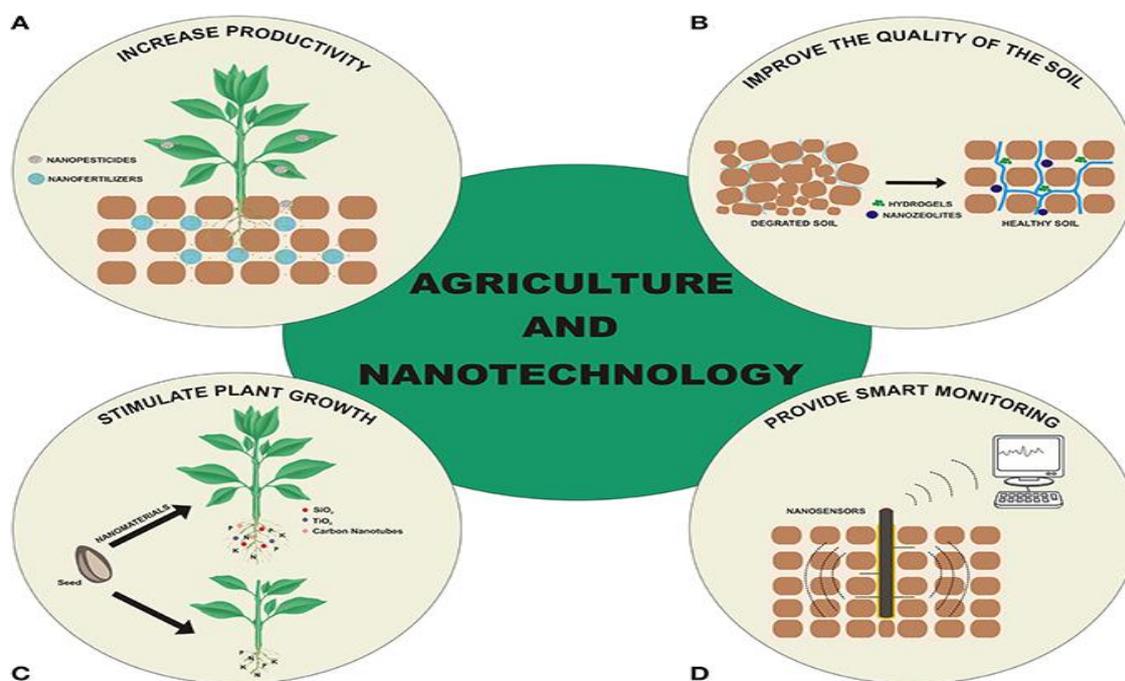
MULTIWALL CNTs

- **Nanorods:-** Nanorods are the nanomaterials that are the object of fundamental and applied research. They may be prepared from carbon, gold, zinc oxide and many other materials. Nanorods have typical length of 10-120 nm. The gold nanorods produces significant physiological changes in watermelon plant and show phytotoxicity at high concentration (Wan et al., 2014). They have the ability to transport auxin growth regulator like 2,4-D which shows significant on the regulation of tobacco cell growth.



Gold Nanorods and Their Plasmonic Properties- Chemical Society Reviews (Rsc Publishing)

Applications of Nanotechnology in Sustainable Agriculture



- Nanofertilizers** :- Nanofertilizers are defined as the materials in the nanometer scale, usually in the form of nanoparticles containing macro and micro nutrients that are provided to crops in a controlled manner. The excessive use of mineral fertilizers and organic materials negatively affected the soil and water quality through out the world. Nanofertilizers could be a crucial development in the protection of environment because they can be applied in smaller quantities compared to traditional fertilizers. Nanofertilizers may contain nano zinc, silica, iron and titanium dioxide ZnCdSe/ZnS core shell QDs, InP/ZnS core shell, Mn/ZnSe QDs, gold nanorods, core shell QDs etc, as well as should endorse control release and improve its quality. Providing balanced nutrients, nanofertilizers facilitate the crop plants to fight various biotic and abiotic stresses. It is reported that in several crops, that use of nanofertilizers and nanomaterials enhanced the growth and yield relative to plant treated with conventional fertilizers. However, the extensive use of nanofertilizers in agriculture

may have some important limitations, which must also be considered and it is crucial to determine the toxicity/biocompatibility of nanofertilizers.

- **Nanopesticides**:-Nanopesticides are plant protection products where nanotechnology is employed to enhance the efficacy or reduce the environmental footprint of a pesticide active ingredient”. The importance of pesticides has been increasing over the last few decades driven by the need to improve overall agricultural productivity, in order to safeguard adequate food availability and sufficiency for the growing global population. The higher dosage of these chemicals on per hectare basis has led to many environmental and health hazards. Nano-pesticides are one of the alternatives to overcome the lacunas of conventional group of insecticides. The major benefits of these nanoparticles includes the improved solubility active ingredients, better stability of formulation, slow release of active ingredient and improvement in mobility caused by smaller particle size and higher surface area. The mode of action against target pests is expected to be enhanced with nanoparticles, as opposed to bulk materials. Meanwhile, we should have a better understanding on the ill effects of these nanopesticides after their application.
- **Nanobiosensors**:-Nanobiosensors are devices that measure a biochemical or biological or any event using electronic, optical, or magnetic technology through a compact probe. Nanobiosensors can be effectively used for sensing a wide variety of fertilizers, herbicide, pesticide, insecticide, pathogens, moisture, and soil pH. Taken together, proper and controlled use of nanobiosensor can support sustainable agriculture for enhancing crop productivity. For addressing problems related to imbalance of phytohormone and related consequences, nanobiosensors have played a pivotal role in terms of detection. Based upon the parameter recorded by the nanosensor, need based actions will increase the crop yields and reduces the unwanted manpower and resources like fertilizers, pesticides etc. The efficiency of biosensor can be improved by increase the detection limit and the overall performance through using nanomaterials.
- **Nanotechnology in Food Pacakaging**:-Highly impermeable packaging nanomaterials are used for protection of food from harmful UV radiations and providing more strength to maintain the food protected from environment increasing

their shelf lives. Nanosensors are used for the detection of chemicals, gases and pathogens in food. In modern terminology a word is given to such type of packaging as smart packaging. sometimes people are not accepting the direct involvement of nanoparticles in food due to some risk factors. Hence it is needed to provide some safety measurements to reduce the risk and human safety.

Future Prospects

Sustainable agriculture must be taken as an ecosystem method, where abiotic–biotic–living beings live in accord with a co-ordinated stability of food chains and their related energy balances. New technologies, modernization, increased in use of nano-chemicals, specialization and government policies are adapted to maximize the production in agriculture. To overcome the situation, it is mandatory to establish the recent technology in the food industry. Therefore, the new and future technology is nanotechnology that possesses very unique property in food supply chain (from the field to table: crop production, use of agro-chemicals such as nanofertilizers, nanopesticides, nanoherbicides, etc., precision farming techniques, intelligent feed, enhancement of food texture and quality, and bioavailability/nutrient values, packaging and labelling, etc.) round the world agricultural sector.

Conclusion

Nanotechnology has recently gained attention due to wide applications in different fields such as in agriculture medicine and environment. The large surface area offered by these tiny nanoparticles makes them efficient to meet the requirements not met by various other control methods. Nanotechnology applications are currently being researched, tested and applied across the entire spectrum of food technology from agriculture to food processing, packaging and even food supplements.

Reference

Nanotechnology in sustainable agriculture

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What is nanotechnology- European commission

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