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Role of Nanotechnology in Agriculture

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Nanotechnology is defined as the engineering of functional systems at the nano-scale which is about 1-100 nm. It is also defined as the science of controlling and understanding the matter of roughly dimensions of 1-100 nm which have unique physical properties and which makes the novel applications always beneficial. In agriculture field, nanotechnology is present in the particulate between 10-1000 nm in size dimensions which are simultaneously colloidal particulate. The escalating applications of nanotechnology in agriculture will continue to rely on the problem-solving ability of the material and are unlikely to adhere very rigidly to the upper time of 100 nm because it is expressed at large scale to inherent the imperfections and complexities of farming system. The farming system and farmers might require nano-materials with the flexible dimension and are efficient in agricultural production system. Nanotechnology used in agriculture is about to reduce the adhere effects of agricultural practices on the environment, ensuring food security or developing nanotech based tools and equipments for improving the productivity.

In today's world, it has made a very powerful impact on all the surroundings. However, the applications of nanotechnology in materials, science and biomass conversion technologies are applied in agriculture on the basis of providing food, feed, fibre, fire and fuels. Other than this, the cost of inputs like chemical fertilizers and pesticides are expected to increase at an alarming rate due to the limited reserves of feed such as natural gas and petroleum. Therefore, in order to overcome these constraints, farming with nanotechnology application is a better option to increase production. For the better advancement in nanotechnology, a several number of techniques can be incorporated which are available for the improvement of precision farming practices at nano-meter. Interestingly, the molecular techniques and the different recent modern biotechnology tools have become very useful and cost-effective in the agricultural conditions and all over the world. However, with the help of modern technologies researchers can detect any pathogen present such modern technologies are biosensors and nanomaterials which have become very helpful in today's world. These different nanotechnologies are listed below that favours the agriculture process.

Nano-Scale Carriers

These nano-scale carriers can be utilized for the efficient delivery of fertilizers, pesticides, herbicides, plant growth regulators etc. However, the mechanism involved in the efficient delivery, better storage and controlling capacity includes encapsulation and entrapment. These nano-carriers helps to improve the stability against degradation in the environment, thus ultimately reduce the amount which is applied and helps to reduce the chemical run off and environmental problems. These carriers are designed through which they can anchor the plant roots to the surrounding soil structure and organic matter.

Microfabricated or nanofabricated xylem vessels

Microfabricated or nanofabricated xylem vessels are designed to study the physio-chemical and biological interactions between plant cell bodies and various disease-causing organisms. These nanofabricated vessels can help in understanding the mechanisms that are involved in disease and ultimately improve the strategy for the treatment of diseases.

Nano-lignocellulosic materials

Lignocellulosic materials are the nano-sized tools which have been obtained from plants. These have also been opened in a new market for innovative and value-added nano-sized materials as like nano-sized cellulosic crystals which has been used as light weight reinforcement in polymeric matrix. These nano-lignocellulosic materials can be applied in food and other packaging, construction in transportation vehicle body structures.

Clay Nanotubes

The clay nanotubes are also known as Halloysite that have been developed as a carrier of pesticides. These are extended and released better in contact with the plants and are also helpful in reduction of 70-80 % of pests in the crops.

Nano-barcode Technology

It is one of the most important and widely used technology in agriculture sector. Nano-barcodes are applied in multiplexed bioassays and are generally encoded because of the possibility of formation of a large number of combinations that makes them attractive for the purpose. The ultra violet lamp and optical microscope are utilized for the identification of micro meter sized glass barcodes which are formed by opening with the rare earth containing specific type of pattern for -different fluorescent objects. Hence, the particles utilized in nano-barcodes can be easily encodable, machine readable, durable and sub-micron-sized taggant particle. The production of nano-barcodes particles is semi-automated and highly scalable. It involves the electroplating of inert metals i.e., silver, gold etc. into the templates that defines the particle diameter and results in striped nano-rods from the templates which are released further. The nano-barcodes improves the plant resistance against various environmental stresses such as drought, salinity, diseases and others that is possible through advancement in the field of biotechnology at the nano-scale. In the near future, more effective identification and utilization of plant gene trait resources are expected to introduce the rapid and cost-effective objects which are capable to detect the pathogens through the nanotechnology-based advanced gene sequencing.

Photocatalyst

Photocatalysis is the combination of two words 'photo' means 'light' and 'catalysis' means 'reaction caused by a catalyst'. Thus, as the word itself suggest that it involves the reaction of catalyst (nanoparticles) with chemical compounds in the presence of light. The mechanism of this reaction is that when nanoparticles of specific compounds are subjected to UV light than the electrons in the outermost shell (valence electrons) are excited resulting in the formation of electron hole pairs that is in the negative electrons and positive holes. These are excellent oxidizing agents includes the metal oxides such as TiO_2, ZnO, SnO_2 etc., as well as sulfides like ZnS. Due to their large surface-to-volume ratio, these photocatalyst have very efficient results in tremendous increment of chemical reactivity and other physico-chemical properties related to some specific conditions such as photocatalysis and photoluminescence. However, this process can be used for the decomposition of many toxic compounds such as pesticides that takes a long time to degrade under normal conditions e.g., pathogens.