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Nanotechnology: A Transformant in Agriculture

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INTRODUCTION

More than 80% of the population in India relies on agriculture for their livelihood. Agriculture is the backbone of the country. But problems like stagnation in crop yield, shortage of labour, declining water table, low soil organic matter, multi-nutrient deficiencies, etc., has become a major concern for the agriculture scientists lately. Specifically in agriculture, technical innovation is of importance with regard to addressing global challenges such as population growth, climate change and the limited availability of important plant nutrients such as phosphorus and potassium. In such case, Nanotechnology, one of the frontier technologies, needs to be explored which could be the answer and apt solution to the aforesaid concerns. Nanomaterials are either amorphous or crystalline particles of organic or inorganic origin having sizes in the range of 1-100 nm. Nanotechnology applied to agricultural production could play a fundamental role for this purpose and research on agricultural applications is ongoing for largely a decade by now. The application of nanomaterials in agriculture particularly aims to reduce applications of plant protection products, minimize nutrient losses in fertilization, and increase yields through optimized nutrient management. Nanotechnology devices and tools, like nanocapsules, nanoparticles and even viral capsids, are examples of uses for the detection and treatment of diseases, the enhancement of nutrients absorption by plants, the delivery of active ingredients to specific sites and water treatment processes. The use of target-specific nanoparticles can reduce the damage to non-target plant tissues and the amount of chemicals released into the environment. Nanotechnology derived devices are also explored in the field of plant breeding and genetic transformation.

Nanotechnology in agriculture

Applications of nanotechnology in materials science and biomass conversion technologies applied in agriculture are the basis of providing food, feed, fibre, fire and fuels. In recent years, agricultural waste products have attracted attention as source of renewable raw materials to be processed in substitution of fossil resources for several different applications as well as a raw material for nanomaterial production.

1. **Nanocomposites**
   Nanocomposites based on biomaterials have beneficial properties compared to traditional micro and macro composite materials and, additionally, their production is more sustainable. Many production processes are being developed nowadays to obtain useful nanocomposites from traditionally harvested materials. Nanoparticles such as nano-sized clays are added to enhance thermal, mechanical, barrier and other properties (Ajayan et al., 2003).
2. **Nanoscale carriers**
   Nanoscale carriers can be utilized for the efficient delivery of fertilizers, pesticides, herbicides, plant growth regulators, etc. The mechanisms involved in the efficient delivery, better storage and controlled release include encapsulation and entrapment, polymers and dendrimers, surface ionic and weak bond attachments among others. These mechanisms help improve stability against degradation in the environment and ultimately reduce the amount to be applied, which reduces chemical runoff and alleviates environmental problems. These carriers can be designed in such a way that they can anchor the plant roots to the surrounding soil structure and organic matter.
3. **Microfabricated xylem vessels**
   Through the advancement in nanofabrication and characterization tools, physio-chemical and biological interactions between plant cell bodies and various disease-causing organisms, i.e., pathogens can be studied. These tools have helped us in understanding the mechanisms involved and ultimately improved the strategies for the treatment of these diseases.
4. **Clay nanotubes**
   Clay nanotubes (Halloysite) have been developed as carriers of pesticides for low cost, extended release and better contact with plants, and they will reduce the amount of pesticides by 70–80%, hence reducing the cost of pesticide and also the impact on water streams.
5. **Photocatalysis**
   One of the processes using nanoparticles is photocatalysis. The mechanism of this reaction is that when nanoparticles of specific compounds are subjected to UV light, the electrons in the outermost shell (valence electrons) are excited resulting in the formation of electron hole pairs. As the size of particles decrease, surface atoms are increased, which results in tremendous increase in chemical reactivity and other physico-chemical properties. So, this process can be used for the decomposition of many toxic compounds such as pesticides, which take a long time to degrade under normal conditions.
6. **Bioremediation of resistant pesticides**
   Nanoparticles can be used for the bioremediation of resistant or slowly degradable compounds like pesticides. These harmful compounds tend to join the positive holes, are degraded and

converted into non-toxic compounds. Otherwise these harmful compounds enter the food chain and result in serious problems for the body. So nanoparticles can be used for environmental safety.

7. **Nano fertilizers**

Fertilizers play an important role by enhancing the agriculture production upto 35-40% of the agriculture productivity. Nano fertilizers might be the best alternative to overcome the problem of eutrophication and enhance nutrient-efficiency. It has been reported that nano fertilizers are more effective than ordinary fertilizers. Significant yield increase has been obtained due to nano-fertilizer application (Trafdar *et al.*, 2012a). To regulate the release of nutrients depending on the crop requirements, attempts are being made to synthesize nonfertilizer. Nano-fertilizer technology is an innovative technology but very merely reported in literature.

CONCLUSION

Nanotechnology a has great potential as it can enhance the quality of life through its applications in various fields like agriculture and the food system. It is capable of being used in agricultural products that would protect plants, monitor its growth and detect diseases. Around the world it has become the future of any nation. Informing the public at large about its advantages is the first step, which will result in tremendous increase in the interest and discovery of new applications in all the domains. In coming years, a tremendous changes are going to take place in the agriculture sector and food industry due to exploration and application of nanotechnology.

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