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Nanofertilizers: Future of Crop Production

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With the global uprising in population and rapid urbanization, agriculturists are left with the critical duty of feeding more people from correspondingly decreasing agricultural fields. Investigations show that, the world population is expected to be 9.1 billion people by 2050, if food consumption in developed countries is coordinated by the other parts of the world and all of these people are to be fed adequately, total food consumption will have to rise by 50–70 %.

Fertilizers have an axial role in enhancing the food production in developing countries especially after the introduction of high yielding and fertilizer responsive crop varieties. In spite of this a yield depression has been observed in majority of field crops as a result of imbalanced fertilization and decreased soil organic matter. Moreover, excessive applications of nitrogen and phosphorus fertilizers affect the groundwater and lead to eutrophication. Such cases along with the fact that the fertilizer use efficiency is about 20-50 percent for nitrogen and 10-25 percent for phosphorus fertilizers implies that food production will have to be much more efficient than ever before.

Nanotechnology is a promising field of interdisciplinary research with enormous potential. It is a novel scientific approach that involves the use of materials and equipment capable of manipulating physical as well as chemical properties of a substance at molecular levels. Nanotechnology is the exploitation of materials at the nanoscale (1-100 nm in any dimension). The high reactivity of nanoparticles is related to their small size and, thus, the possession of a large surface area which confers them with superior attributes over larger-sized particles of similar chemistry. This improved quality of materials at the nanoscale has led to the use of nanomaterials in a variety of applications.

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Mode of application of nano fertilizer

Two strategies for nanomaterial delivery into plants can be envisaged. On the one hand, micronutrients from metallic elements (Zn, Fe, Cu, Mn,Mg, Ni) can be delivered as nanoparticles which can either be taken up directly by the plant or be solubilized in the rhizosphere prior to uptake of the cognate ion. Bulk rock phosphate particles can be prepared as nano-formulations by grinding and supplied to the plant as nanoparticles.

On the other hand, mineral nutrients can be encapsulated in nano-polymer that also could either be directly absorbed by the plant, releasing the cognate nutrient in plants, or be engineered to timely dissolve in the rhizosphere, releasing the encapsulated nutrients in sync with the plant's need. In addition to the individual mineral nutrients, composite nanoparticles of different but compatible nutrients also can be delivered via soil or foliar application into plant tissues, where they slowly dissolve to release the cognate ions for plant assimilation, goaded by specific environment.

Benefits of nano-fertilizer as compared to bulk fertilizer

Irrespective of the uptake mechanism, the cognate nutrients in nano formulations are supposed to be released for plant use in a more efficient manner than those from bulk fertilizers. The plant use efficiency of the current bulk fertilizers is marred by high leaching of nutrients away from the rhizosphere, their fixation in the soil to forms that are not readily bioavailable to the plant, as well as other forms of losses such as volatilization. Nanotechnology offers a great opportunity to enhance the use efficiency of fertilizers. Slow release of fertilizers implies that both leaching and fixation of nutrients could be reduced, with such release permitting a better timing of nutrient availability and plant nutrient need. In the case of nutrient-deficient soils, because nanoparticles inherently release soluble ions faster than bulk particles, enhanced and sustained release of nutrients from nano materials will be important in supplying nutrients in a quick and timely manner, in contrast to slow release. Slow release of nutrient element negates the possibility of attainment of bio-toxic levels of mineral nutrients and reduces loss due to leaching or fixation.

Ethical and safety issues in using nano-fertilizer

Although nanotechnology has incredible potential to revolutionize many aspects of human life, the benefits may come with some price. One of the major questions faced by the

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world before accepting nanotechnology is whether the unknown risks of nanoparticles involving their environmental and health impact prevail over their potential benefits. The risks associated with the application of nanoparticles are yet to be evaluated before fully implementing this technology. This consideration has developed "nanotoxicology," which is responsible for assessing toxicological potential as well as promoting safe design and use of nanoparticles. A systematic and thorough quantitative analysis regarding the potential health impacts, environmental clearance, and safe disposal of nanoparticles can lead to improvements in designing further applications of nanotechnology Although no direct human disease has been linked to nanoparticles so far, early experimental studies indicate that nanoparticles could initiate adverse biological responses that can lead to toxicological outcomes .Nanoparticles which constitute a part of ultrafine particulate matter can enter in the human/animal system through oral, respiratory, or intradermal routes. Currently, there is a common assumption that the small size of nanoparticles allows them to easily enter tissues, cells, and organelles and interact with functional biomolecular structures (i.e. DNA, ribosomes) since the actual physical size of an engineered nanostructure is similar to many biological molecules (e.g., antibodies, proteins) and structures (e.g., viruses).

Conclusion

The use of nanomaterial can increase crop yield by increasing uptake of fertilizer nutrients by plant and photosynthetic activity and suppress phytopathogenic activity through a variety of mechanism, production of reactive oxygen species. Additional, several researchers reported that that decrease in size of nanomaterial increase the surface mass ratio of particles, Therefore, nano-fertilizers can provide balanced nutrition to crops during the growth period, which in turn improves agricultural production

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