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Nanofertilizers: "An ecofriendly and efficient approach for sustainable agricultural production"

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Introduction

Agriculture is the major sector related to production of wide variety of crop produce which is currently representing worlds multitrillion dollar industry (Malhotra, 2016). With, rapid rise in human population which may reach 9.6 billion by 2050 and limited resources, it is need of the hour to develop efficient agriculture system to cope up with growing hunger and poverty (Zhang *et al.*, 2015). However extensive chemical fertilizer use is required to meet the growing demand of food production and to support economic development globally, but their application over extended period of time has caused serious environmental constraints worldwide including water eutrophication, air pollution, soil quality degradation and ground water pollution (Congreves*et al.*, 2015). Additionally, profit margin for growers is reduced from over application of chemical fertilizers which cost them deliberately. High release rates of conventional fertilizers lead to low nutrient use efficiency by plants which further leads to transformation of fertilizers or nutrients to forms which are not bioavailable to crops (Chhipa *et al.*, 2017). Thus, interest should be laid towards development of new innovative fertilizer source so as to increase fertilizer use efficiency (Eerd *et al.*, 2018) such as split or localized application, precision fertilization, fertigation and use of nanofertilizers.

Application of nanotechnolology in context of sustainable agriculture for new fertilizer development is regarded as most promising option for global horticulture production to meet growing food demand of population with added benefits of sustainability under current climate change scenario (Raliya *et al.*, 2017). When nanofertilizers are applied to plants in

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controlled manner then these can gradually feed plants along with other benefits of minimizing leaching and volatization, fertilizer use efficiency and less environmental hazards (Solanki *et al.*, 2016). Various nanofertilizers used have potentially increased crop productivity by enhancing seed germination, photosynthesis, seedling growth, nitrogen metabolism and carbohydrate and protein synthesis beside stress tolerance. Further, these nanoparticles can be applied in relatively smaller amount which can reduce transport expenditure and increase ease of application. However, there are some limitations which are to be resolved which effects their full implementation in the market.

Benefits of Nanofertilizer

Nanofertilizer technology is a boon to existing agricultural as it is very innovative and scanty. Conventional fertilizers have 30-35%, 18-20% and 35-40% of nutrient use efficiency for nitrogen, phosphorus and potassium respectively. Further due to considerable surface area and small particle size, various types of nutrients are stored in plentiful quantity for long duration with increased utilization and bioavailability of the nano-fertilizers without any relevant side effects (Preetha *et al.*, 2017). Small size of nanoparticles makes them very useful in providing site for plant food metabolism, which results in more plant development by consuming less amount of essential nutrients and these are extremely soluble in water. The increased performance and effectiveness is achieved when these microparticles are combined with fertilizers, which slowly releases nutrients and makes these available to crops over entire growing cycle. This mitigation measure prevents loss of nitrogen through process of volatization, denitrificarion, leaching and fixing into Nitrate (NO3-) and Nitrate (NO3-) in the soil.

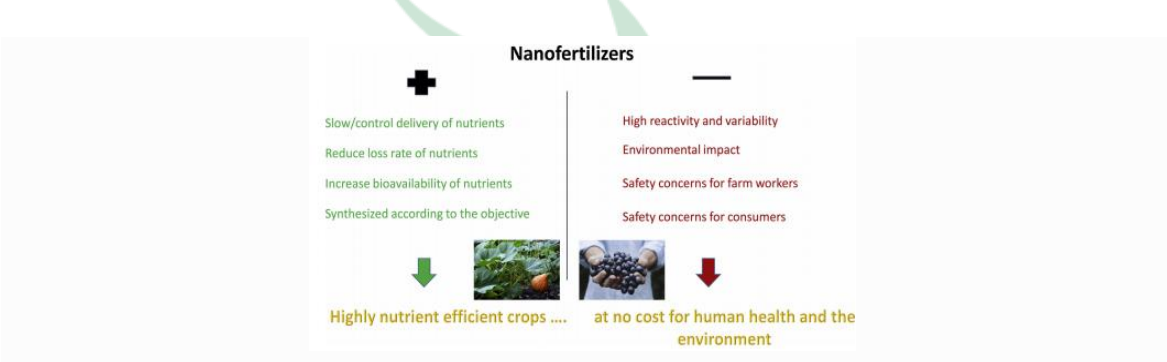

Fig 1. Advantages and limitations of Nano-fertilizers

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Various Nanoparticles based delivery systems

Nano-material based fertilizers have a slow nutrient release effect, fertilizers particles are held firmly due to high surface tension provided by the surface coatings of nanomaterials on the materials. Several nanoparticle-based delivery systems are used (Mahanta *et al.*, 2019).

- Chemical system: It includes slow release nano coated particles of sulfur which supply primary nutrient elements along with sulfur. Efficiency and reliability of urea and phosphoric fertilizers can be improved by coating them with nanosized materials. Further for various biomedical applications kaolin and polymeric nanoparticles can also be used (Juthery *et al.*, 2019).
- Biological system: The storage, preparation and application of bio fertilizer are crucial for vital success in the field. Many tolerant formulations are obtained by coating of wetting agents on types of particles.
- Direct delivery of nanofertilizers in field: Applications of nanofertilizers in the field determines their efficacy and environmental effects (Juthery *et al.*, 2019). The restrictions associated with the droplet size of foliar sprays can be resolved by using nanosized fertilizer.
- Release of Nano fertilizers in controlled manner: For stable production of nanofertilizers variety of methods like NanoFerts are used. These are combined with materials like Hydrogels, special films or other biopolymers such as Chitosan to decrease the uncontrolled release (Wilson *et al.*, 2008). Various material aggregate fertilizers with mineral nanoparticles which are obtained from ceramic material or clay in soil are used for producing controlled release pots, blocks or films. These can satisfy unique need of various plants. In order to avoid their release to environment foliar spray is the best process which can be taken into consideration along with encapsulated organic nanoparticles. It should also be ensured that the quantity of nutrient applied to soil should be sufficient for crop production stage.

Agricultural benefits of nano-fertilizers

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Over the past few years, studies were conducted which idealises the subsequent increased use of nano-fertilizers which has also advanced the quality parameters and crop yield. The reason behind this is primarily based on enhanced photosynthesis from increased growth rate of different plant parts and enhanced metabolic activity, leading to higher translocation and accumulation of photosynthesis. Nutrient availability of plants can be greatly improved by Nano-fertilizers. Due to this various quality parameters like oil, protein and sugar can be monitored in plants by increasing the rate of synthesis and chemical reaction in plant cells. Total starch, carbohydrate, chlorophyll, indole-3-acetic acid and protein contents in crops was increased by Nano formulation of iron and zinc (Juthery *et al.*, 2019). These nanoparticles are also reported to provide disease resistance. The Nano-nutrients provides protection to the plants from harmful pests, various bio-diversity stresses and nutrient deficiency. Seed germination rates and growth parameters of plants are also influenced by nano-fertilizers. Studies on zinc oxide nano-formulation demonstrated higher rate of germination and root vigour as compared to bulk amount of zinc sulphate (Kashyap *et al.*, 2015). Application of nano-fertilizers makes the fruits to be more nutritious and succulent than their natural form.

Conclusion

Nano nutrients made from controlled formulations are found to be more economical and efficient than conventional ones. Yield of crops, natural resources protection and reduction of cost of fertilizers depends on application of different types of nano-fertilizers. Use of nano-fertilizers in agriculture fields increases the nutrient use efficiency of plants. Application of appropriate dose and concentration of nano-fertilizers promote good crop growth and yield. The nano-fertilizers promote good crop growth and yield by proper dosage and concentration. But if its amount is increased upto certain level it may have some inhibitory effect on the plants. Thus, optimal doses of nanofertilizers has to be optimized upto certain cap on different crops in near future, in order to sustain highly eco-friendly and productive production system.

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