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Nano-Fertilizers in Agriculture: Introduction and Opportunities

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INTRODUCTION

Nanotechnology is science of utilizing nanoparticles, having size dimensions ranging from 1-100 nm for various purposes like, medicines, agriculture, physics, chemistry, food and energy industry to manipulation matter at nanoscale. Along with other fields, nanotechnology is also influencing agriculture sector as well. Nanotechnology is a new step towards solving long term challenges emerged due to modern intensive agriculture (Agrawal and Rathore, 2014). Nanotechnology in agriculture is mainly concerned with Nano-pesticides, Nano-herbicide and Nano-fertilizers. Among these technologies, nano-fertilizers are the most impactful application of nanotechnology in agriculture so far. Nano-fertilizers are aimed to increase nutrient use efficiency (NUE) by making more nutrients available to leaves surface (Suppan, 2013). Nanoparticles have some characteristics features like, large specific surface area, catalytic reactivity, electronic states and unique magnetic/optical properties. Large specific surface area of nanoparticles helps in enhancing intractability of nanoparticles to target sites. The reactivity of nanoparticles is higher than that of bulk materials. (Agrawal and Rathore, 2014). Nano-fertilizers have the potential to meet plant nutrition needs while also ensuring crop production systems' sustainability, all without affecting crop yield.

Nano-fertilizers

Nano-fertilizers are nano nutrient carriers, whose substrates in the range of 1–100 nm and are able to provide nutrients to a plant's without associated environmental hazard. Nano-fertilizers are a relatively new technology, and little research has been done on nutrient dynamics in soils nourished by nano-fertilizers. Little work has been done because it is a fairly new technology, but according to published literature, nano-fertilizers are slow and sustained release fertilizers unlike most other conventionally used fertilizers.

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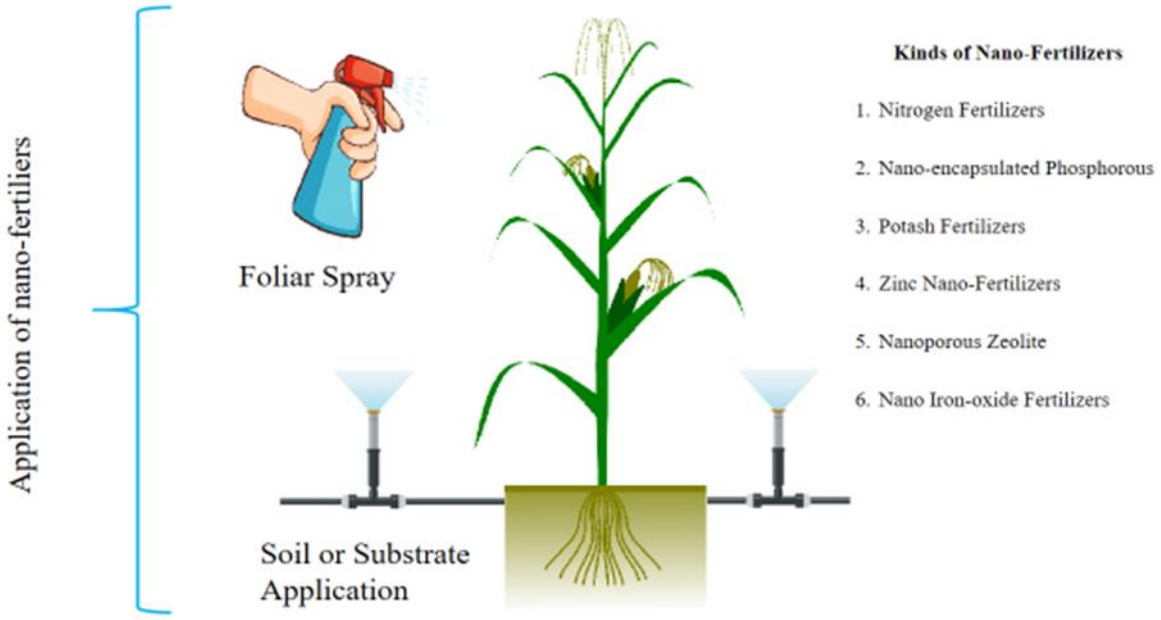
These can be applied either through foliar application or by soil or substrate application. There are several kind of nano-fertilizers used in agriculture, which are following:

1. Nitrogen Fertilizers
2. Nano-encapsulated Phosphorous
3. Potash Fertilizers
4. Zinc Nano-Fertilizers
5. Nano porous Zeolite
6. Nano Iron-oxide Fertilizers



Advantages of Nano-fertilizers over conventional fertilizers

1. Nano-fertilizers provide nutrients to crop gradually in contrast to mineral fertilizers which releases nutrients rapidly and spontaneously.
2. Due to higher "Nutrient Use Efficiency" nutrient absorption and utilization is considerably more and losses due to leaching and volatilization are reduced.
3. Nanoparticles from nano-fertilizers can pass through the plasmodesmata, resulting in an effective supply of nutrients to the sink.
4. Nano-fertilizers can be applied in small quantities as they have significantly less losses than synthetic fertilizers. In Synthetic fertilizers losses mostly occurs due to leaching, surface runoff and volatilization.
5. Nano-fertilizers offers a great potential to reduced environmental pollution due to being applied in smaller quantities.
6. Compared to conventional synthetic fertilizer, nano-fertilizer have higher solubility and diffusibility.
7. The smart polymer coated nano-fertilizer has a thin coating that encapsulates the nanoparticles, avoiding premature contact with soil and water, thus ignoring any nutrient loss. In addition to this, nutrients will be available to plants as soon as the nutrients are released.

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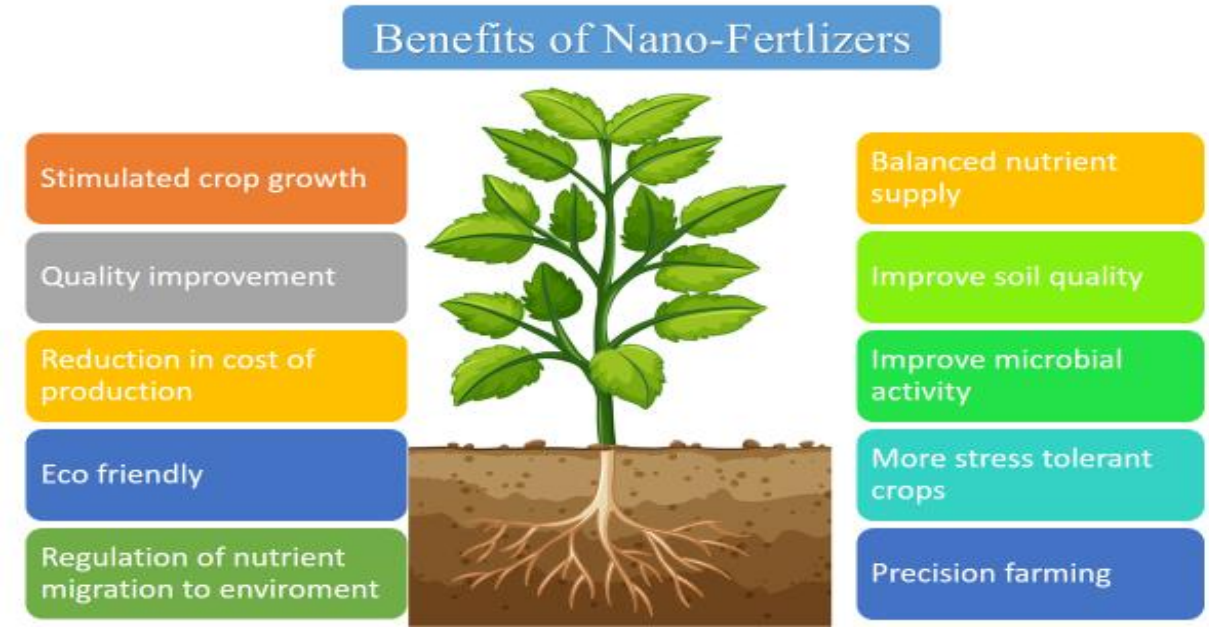

Limitations of Nano-fertilizers

Nano-fertilizers offer many advantages in terms of sustainable crop production, but currently hindered due to research gaps and lack of close monitoring. There are some restrictions in terms of the lack of laws that exist. Some of the limitations of nano-fertilizers are listed below.

1. Nano-fertilizer's legislation and related risk management continue to be a major constraint in advocating and promoting nano-fertilizers for sustainable crop production.
2. A major constraint in nano-fertilizer adoption is lack of legislation and related risk management.
3. Nano-fertilizer's manufacturing and availability is another limiting factor.
4. The higher expense of producing nano-fertilizers adds to the difficulty of implementing them in agricultural production.
5. Due to lack of standardization, many products are labeled as nano-fertilizers although they are submicron and micron in size. It can lead to conflicting effects of the same nanomaterial under different pedoclimatic climatic conditions. It is feared that this dilemma will continue until appropriate standards and laws come into force.

CONCLUSIONS

The use of nano-fertilizers with organic and biofertilizers has great potential for reducing environmental pollution as they significantly reduce losses and increase absorption. In addition to improving the environment, nano-fertilizers also improve germination rate and plant growth attributes like plant height, biomass accumulation, primary & secondary root and rootlets number, leaf chlorophyll content and fruit antioxidant content. In addition, Nano-fertilizers provides a controlled sustained release of nutrients with a nanoparticle coating that improves nutrient utilization and photosynthetically active radiation (PAR) absorption. Thus significantly reducing nutrient losses. However, the future of nano-fertilizers for sustainable crop production and as a nutrient source for crops depend on a variety of factors, including effective rules and regulations and production of novel nano-fertilizers products. There is also an urgent need to carry out rigorous field and greenhouse studies to standardize nanomaterial formulations and assess performance. Finally, researchers and legislators must take full benefits of nano-

fertilizers for sustainable crop production under changing climatic conditions.

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