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Application of Nano fertilizers on Vegetable Production: A review

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ABSTRACT

Agriculture is the backbone of many developing countries, the majority of the country's population depends on it for their livelihood. The total populace is developing by around 83 million individuals every year, so there is a need to increment rural usefulness. At present, promising production of vegetable crops can be accomplished by expanding the arable land or by expanding crop yields by working on the productivity of the resources utilized. For these purposes farmers had been utilizing chemical fertilizers and irrigation water indiscriminately on about 60% of our currently arable agricultural land which resulted in number of negative consequences. Therefore, there has been a great scope to utilize present-day innovations like nanotechnology (NT), since nano-fertilizers enhance the plant's ability to absorb nutrients and agronomic structures of the soil that enhance plant growth and productivity. Economically nanotechnology has expanded the effectiveness of nano compost fixings and added to expanded usefulness and yield. In this review, extensive research is shown on nanotechnology as an effective way to address the problems of fertilizer losses, overcome the negative impacts of indiscriminate uses of fertilizers and discusses the findings of field research and the application of nano-fertilizers on plants and their impact on vegetable crops.

Key words: *Growth, Nano-fertilizers, Production and Vegetables*

Introduction

Many issues confront Indian agriculture, including population increase, shrinking territories, restricted water supply, unequal fertilization and carbon dioxide in low-lying soils all while being exposed to green variations and climate change. Chemical fertilizers and irrigation water are used indiscriminately on about 60% of our currently arable agricultural land. High fertilizer use and insufficient organic use have resulted in negative consequences such as decreased soil fertility, soil erosion, air permeability, water retention capacity, negative effects on soil health biotics, food poisoning and pesticide residues, soil and air pollution and health hazards. Therefore to achieve the concept of sustainable agriculture, it is necessary to intervene the modern agriculture with an innovative and potential technology such as nanotechnology. Use of nano-fertilizer facilitates the slow and steady release of nutrients, hence enhancing nutrients use efficiency by reducing the loss of nutrients. They have a higher surface region and molecule size than the pore size of the roots and leaves of the plant which can increase entrance into the plant and further develop take-up and supplement the use productivity of the compost. Research work on the nanotechnology-based conveyance of agrarian synthetic substances has been immediately finished by non-industrial nations like China and their field applications are normal in the following 5-10 years. Be that as it may, their prosperity relies upon many elements like market interest, overall revenue, natural advantages, risk appraisal and the board approaches behind the scenes of other cut-throat innovations.

The appropriate utilization of nutrients is extremely low and ought to subsequently be improved by the transformation of fertilizers as nano-fertilizer. Nano-fertilizers are required in little amounts and consequently will lessen the consequences of excessive use of fertilizers. The utilization of nano-technology in the cultivation of crops is one of the proposed tools for sustainable production.

1. Based on mineral elements (Butt and Naseer, 2020):

a. **Macro nano-fertilizers:** Macronutrients are minerals that plants need in enormous amounts. These includes nitrogen, phosphorus, potassium, calcium, sulphur and magnesium.

b. **Micro nano-fertilizers:** Micronutrients are synthetic substances that are required in modest quantities for the development and advancement of plants. These micronutrients are manganese, boron, molybdenum, iron, zinc, chloride and copper.

2. Based on Categories

a. **Nanoscale fertilizers:** The nutrients mineral are prepared as nanoparticles.

b. **Nanoscale additive fertilizers:** It is such type of fertilizers, where the conventional fertilizers are prepared with nano addition.

c. **Nanoscale coating fertilizers:** It is such type of fertilizers where, the conventional fertilizers are plated by nanoparticles.

3. Based on Activity/action

a. Controlled-release fertilizers (CRFs)

b. Slow-release fertilizers (SRFs)

CRFs and SRFs are utilized alternately yet are different. The term CRF is generally applied to composts in which the rate, pattern and deliverytime are perceived and controllable through planning. Whereas, SRFs are set apart by supplement discharge at a slower ratein any case, the rate and time of delivery are not controlled (Trenkel, 2010 and Jia *et al*., 2020. These elements might be affected by dealing with conditions like a storage facility, transport and conveyance in the field, notwithstanding soil conditions, for example; dampness content, dissolving and drying, defrosting and freezing and organic activity (Shaviv and Mikkelsen, 1993 and Shaviv, 2001).

Benefits and challenges of using Nano fertilizers

Emerging technologyis continually advancing particularly in current farming. Worry for the climate is a significant variable given that natural resources are turning out to be progressively scant and the impacts of environmental change are being tremendous. Looking for progress and populace development introduced significant requirements, like higher food creation in more modest regions and less time. Along these lines, the utilization of Nano manures in horticulture can fill in as an alliance to accomplish supportability, particularly in food production all over the world.

Advantages and Disadvantages of nano-fertilizers

By decently providing nutrients, nano-particles

Types of Nano fertilizers

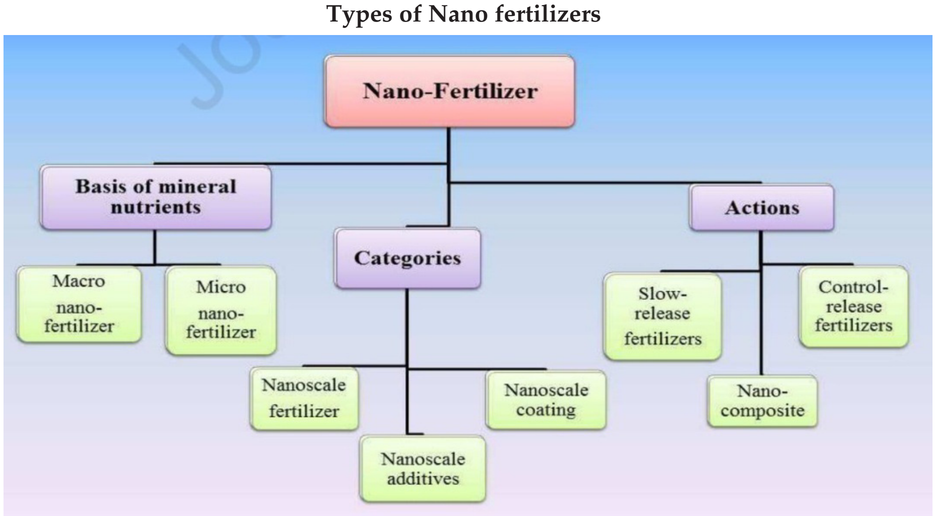

Fig. 1.

Advantages	Disadvantages
Possibility to act as a great nutrient release mechanism	Need for life cycle studies
Reducing nutrient loss to the environment	Food security
Numerous synthesis approaches	Lack of long-term environmental studies

helps eliminate biotic and abiotic stresses by the plants. Nonetheless, heavy utilization of Nano-fertilizers in horticulture might have a few issues and limits which require unique consideration (Younes, *et al.*, 2020).

Mechanism of nanoparticles entry into plant cells

Foliar application of nano-fertilizers enter a plant system through leaf cuticles, trichomes, stomata and hydathodes and by the expansion of soil through the root tip, horizontal roots, rhizosphere wounds and root intersections. The foliar treatment of nanoparticles is a functioning strategy for using a few micronutrients since it requires the least rates and micronutrients that don't communicate immediately with the soil, hence staying away from the negative impacts (Volkweiss, 1991)

Effect of nano-fertilizers on seed germination

The execution of multi-walled carbon nanotubes (MWCNTs) emphatically influences seed germination for different kinds of crops like tomatoes, corn and garlic (Biris and Khodakovskaya, 2011, Anita and Rao, 2014). Comparable outcomes were found by Khodakovskaya *et al.* 2009, who observed that, multi-walled carbon nanotubes can penetrate tomato seeds and raise the germination percentage by further improving water absorption. The seed germination percentage after 20 days of the treatment by MWCNTs was more than 90 % compared 71 % for control. Haghighi and Teixeira da Silva (2014) showed that CNTs impacted the germination of tomato, onion, turnip and radish seeds. They found that, CNTs at 10 - 40 mg/l improved tomato and onion germination. However, CNTs at 40 mg/l have a harmful and toxic effect on the germination of onion seeds and seedlings. This outcome proposes that the productivity of CNTs might depend on the sort of plant and the concentration of CNTs on the outer layer of the testa and root. Raskar and Laware (2014) showed that the utilization of ZnO-NPs at lower concentration i.e., 20 µg m/L increase the germination of onion seed by 96.52 % yet at a higher fixation (40 µg m/l) reduce seed germination by 78.28%. Going against the norm, Feizi *et al.* (2013) found that, the most noteworthy level of fennel seed germination (around 76 %) was found in application of 60 mg/l titanium dioxide nanoparticles (TiO_2-NPs), while most TiO_2 particles reduced the germination percentage by about 41 % in 60 mg/l. However, seeds treated with TiO_2-NPs had a growth rate of 39.5% higher than that of control and was 83% greater than that from the concentration of TiO_2 particles. The higher germination percentage in TiO_2-NPs might be due to image closure and active oxygen species (such as superoxide and hydroxide anions) that increase seed stress resistance and improve efficiency to absorb the required water and oxygen. Singh *et al.* (2013) showed that tomato seeds treated in concentration 9 µM of ZnO-NPs recorded a very high germination percentage compared to control and seed treated with ZnO (4.5 µM). Additionally, radicle length and plumule length was also shown excellent with ZnO-NPs.

Effect of nano-fertilizers on Seedling growth

Haghighi and Teixeira da Silva (2014) observed that, the pace of germination of tomato, onion, rapeseed and radish seeds in a nursery utilizing different concentrations of CNTs (0, 10, 20 and 40 mg/l depends

Table 1. Effects of nano-fertilizers in different crops:

Nano fertilizers	Crops	Effects	Reference
N	*Phaseolus vulgaris* L.	Contributed to plant growth	Medeiros *et al.*, 2010.
K	*Vigna unguiculata* L.	Improved water balance and breathing	Prazeres *et al.*, 2015.
Mg	*Musa spp.*	plant growth, nutrients and carbohydrates status.	Prazeres and silva S., 2015.
Fe and Cu	*Lactuca sativa*	growth, water content, and catalase activity	Trujillo-Reyes *et al.*, 2014
Fe and Zn	*Cucumis sativus*	production of antioxidants enzymes	Ahmed *et al.*, 2018
Cu	*Solanum lycopersicon*	mitotic index	Ahmed *et al.*, 2018

on the (CNTs) carbon nanotubes fixation and the plant type. The new weight of radish seedlings diminished with rising carbon fixations. Running against the norm, the dry weight of tomatoes and radish shoots increased by increasing the concentration of CNTs from 10 mg/l to 40 mg/l. However, CNTs didn't influence rapeseed development. Begum *et al.* (2011) found that different graphene fixations impacted the seedling development of cabbage, tomato and red spinach. While, the concentration @ 50 mg/l increased the development pace of tomato seedlings without any indication of critical poisonousness, 500 mg/l made a slight difference, while 2000 mg/l showed a significant impact on cabbage, tomato and red spinach seedlings.

Effect of nano-fertilizers on Plant growth and yield

Zheng *et al.* (2005) observed that the growth of spinach plants was altogether improved by low concentrations of TiO_2-NPs compared with higher concentration. These impacts might be brought about by nano-particles that advance photosynthesis and nitrogen digestion (Hong *et al.*, 2005). Pradhan *et al.* (2013) recommended that, Mn-NPs lead to an increase in growth of bean at 52% and 38% root. Mahmoud *et al.* (2018) found that, utilization of chitosan NPs (Ch-NPS) as a foliar spray in snap bean plants @ 60 mg/l resulted to maximum plant growth i.e., plant height, number of leaves, branches per plant and fresh and dry weight of plants. Bonilla-Bird *et al.* (2020) reported that the growth of potato plants, estimated as plant biomass is not impacted by different copper sources compared with controls, while tuber lengths were increased by the utilization of copper oxide nanoparticles @25 mg kg^{-1} compared with copper oxide and control. These effects may be due to the activation of various biological responses in plants depending on the chemical composition of chitosan and the level of use (Malerba and Cerana, 2016). Hernández-Hernández *et al.* (2019) reported an increased yield of tomato by upto 21% with 10 mg l^{-1} of Se NPs. The application of Se and Cu NPs also was found to increase the chlorophyll content, vitamin C, glutathione, 2,22-azino-bis(3-ethylbenzthiazolin-6-sulfonic acid (ABTS), superoxide dismutase (SOD), glutathione peroxidase (GPX) and phenylalanine ammonia liasa (PAL) in leaves and increased vitamin C, glutathione, flavonoids, firmness, total soluble solids and titratable acidity in fruits.

Effect of nano-fertilizers in disease resistance

Nutrients are significant in smothering plant infections. Elmer and White (2016) found that CuO nanoparticles utilized as a foliar spray on tomato leaves and eggplants were exceptionally compelling in controlling diseases (*Verticillium* wilt fungus) and increasing yields. Stampoulis *et al.* (2009) showed that the concentration of Ag-NPs in zucchini plants was 4.7 times more than that of plants given an equivalent amount. Giannousi *et al.* (2013) showed that spraying of mixtures of nanoparticles CuO, Cu_2O and Cu/Cu_2O from sizes (11 to 14 nm) and Cu fungicides were found to control decay of *Phytophthorainfestans*. Tomato plants treated with Cu-based NPs are more efficient than copper-based agro-chemicals. Deepak *et al.* (2013) showed that the CuSO4 and Na2B4O7 nanoparticles were exceptionally effective in controlling rust in the peas, between 15 micronutrients in a nano-like manner.

Effect of nano-fertilizers on Post-harvest of vegetables

Food packaging is important for food storage, especially those foods that can be eaten quickly. Ingredients used in food supplementation should be safe, lightweight, inexpensive, recycled, and resistant to physical and environmental pressures. In addition, the penetration of gas and water through packaging materials is extremely important, especially for vegetables and fruits that require complex conditions due to the shelf life which relies on oxygen supply. Nano-technology is an innovative intervention which can efficiently protect food and keep it fresh for a long time. Nano-matadium is mixed with polymeric packaging to produce so-called nano-composites with promising properties and may improve the quality and characteristics of food packaging (Youssef *et al.,* 2019).

Copper nanoparticles have led to an increase in the hardness of the tomato fruit due to the hardening of the pericarp cell wall (López-Vargas *et al.*, 2018). This effect was due to an increase in the activity of the enzyme phenylalanine ammonia-lyase. As fruit hardness increases, shelf life can be extended (Wang *et al.*, 2013). Similarly, Zhu *et al.* (2017) argued that using selenium could be a good way to maintain maturity and extend the shelf life of tomato fruit.

Effect of nano-fertilizers on Salinity stress

The plants tolerance to stress conditions such as;

high salt concentration is exceptionally low. One more specialized method for expanding plant protection from stress is to introduce a gene that incorporates a particular protein that helps to overcome such adverse effect. However, this innovation is tedious and labor-intensive (Jeelani *et al.*, 2020). Siddiqui. Whaibi (2014) observed that chlorophyll content expanded with photosynthetic action and plant biomass and seed germination and development were further developed while utilizing 1.5-7.5 g/l of SiO2-NPs in Cucurbitapepo L. underexcess salt.

Prospect

The actual implementation of nano-fertilizers is still a long way to go. Developing countries like India and several others have comprehensive agricultural practices confined in rural areas. Finding support from farmers in exciting situations as well as progressive farmer's organizations is a challenge that can make a huge difference in research. Therefore, there is a need to make concerted efforts to raise awareness among the farming community about the benefits of nano-fertilizers in sustainable crop production. In many regions, there is a steady decline in the prevailing climate pattern as to which type of fertilizer is best for which soil. Although efforts have, in the past, convinced farmers that fertilizer differs from manure in terms of chemical composition and method. However, the availability of fertilizers at any time of the year and to a large extent also presents a major challenge. Therefore, researchers in collaboration with farmers should embark on a concerted and collaborative effortto understand the exact scientific reason for using a nano-fertilizer.

Conclusion

Utilizations of nanotechnology in materials science and biomass change advancements applied in horticulture are to be focused for producing more food, feed, fiberand energy. The expense of creating inputs like synthetic fertilizers and pesticides is incrementing at a disturbing rate because of restricted stores of fuel like flammable gas and oil. In order to overcome the adverse effect on production, sustainable cultivation practice is a superior choice to decrease input costs and expand yield. Through progressions in nanotechnology, a few cutting-edge procedures are accessible to improve precise cultivation practices that will permit exact control.

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