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Application of Nanotechnology in Vegetable Crops

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Abstract

Nanotechnology is one of the important technologies of recent times. To meet the needs and demands of increasing population globally, there is a need to increase the production and productivity of vegetable crops by utilizing the limited resources available. Nanotechnology is a new perspective of precision farming which maximizes the output from crops while minimizing the inputs such as fertilizers, pesticides, fungicides and herbicides. Nano encapsulation reduces pollution and protects theenvironment by reducing leaching and evaporation of harmful substances. In vegetables, nanotechnology has vivid applications in crop growth, plant protection, genetic engineering and post-harvest. Hence, the use of nanotechnology can significantly contribute to sustainable intensification of vegetable production.

Keywords: Nanotechnology, Precision farming, Vegetable production.

Introduction:

Nanotechnology has attained immense importance in the recent years due it its wide range of applications. Nanotechnology involves use of nanomaterials or nano particles which have particle size ranging from 1 to100 nm in atleast one dimension. Nanomaterials have wider applications in vegetables. They are promising agents which promote plant growth by providing nutrition and plant protection. Nano-encapsulated conventional fertilizers, pesticides and herbicides helps in slow and controlled release of nutrients and agrochemicals

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resulting in precise dosage to the plants.Vegetables are voracious nutrient mining crops having a very huge requirement of nitrogen and phosphorus so development of nano form of these will be suitable for the different vegetable crops to enhance the nutritional quality (Chhipa, 2017).Nanotechnology takes a pivotal role in vivid crop breeding plans to enhance the yield and quality enhancement (Saidaiah and Geetha, 2021).

Synthesis of nanomaterials:

Nanomaterials can be synthesized by physical, chemical and biological methods. Among which green or biological method is found to be effective as it is simple and eco-friendly as it prevents pollution by minimizing the production of harmful chemicals. Hence production of nano chemicals through green methods is becoming popular.Biological methods include the extraction of nanomaterialsfrombacteria,fungi and plants.

Application in vegetable crops:

Nanotechnology is found useful in all stages of production, storage, processing, packaging of vegetables. Nanotechnology helps to revolutionize horticulture and food industry.Nanomaterialscommonly used in vegetables include silver nanoparticles, zinc oxide nanoparticles, titanium dioxide nanoparticles. The benefits of nanotechnology in vegetable production are enormous. These include control of insect pests usingnano pesticides and nano insecticides, increase in vegetable production and productivity using nanoparticles encapsulated fertilizers and biofertilizers.

Crop growth:

Essential nutrients play a vital role in plant growth and development. These nutrients can be supplied by application of nano fertilizers. Nano fertilizers are fertilizers coated with nano materials. They improve yield in vegetables by slow release and increased availability of nutrients to plants as they hold the nutrients more strongly due to higher surface tension than conventional surfaces. They improve the nutrient use efficiency by decreasing the immobilization. Compared to synthetic fertilizers, they have lower impact on environment by reducing agricultural waste production and runoff of nutrients through leaching and volatilization.Nano fertilizer improved the plant growth, yield and fruit quality of cucumber and it can be used as an alternative to mineral fertilizers.(Merghany*et al.,* 2019).The presence of zinc and sulphur nanoparticles affected growth of broad bean crop at different concentration (Ghidan*et al.*, 2020).

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Nano formulations of micronutrients when sprayed on plants or applied to the soil will prevent various micronutrient deficiencies.Among which zinc deficiency is most common in vegetables which causes various physiological disorders like little leaf in brinjal. Use of zinc oxide nano particles-based fertilizers are useful to promote growth by supplying zinc micronutrient and due to its anti-bacterial properties.Nano sensors help in detection of the level of plant nutrients. Nano sensors based smart delivery systems could help in the efficient use of natural resources like water, nutrients and agrochemicals by precision farming (Rai*et al.*, 2012). Thus, use of nano sensors is highly recommended to improve yield by monitoring nutrient levels and improving efficiency of nutrients and other resources by plants.

Plant protection:

Nano sensors are useful for detection and diagnosis of diseases and viruses in vegetables. Verdoodt*et al.* (2017) invented gold nanoparticle based immune-sensor for quantitative analysis of Gram-positive bacteria. Nano materials with micronutrients such as Copper and Zinc favour the activation of enzymes and the synthesis of biomolecules involved in plant defence. The use of nanomaterials is an alternative solution for control of pests, pathogens and weeds. Several nanomaterials act as antimicrobial agents are used in food packing among which silver nanomaterials are of great interest as they have high surface area compared to bulk silver which results in enhanced antimicrobial properties.

Nano pesticide formulation containsengineered nanomaterials as active ingredients with biocidal properties. It enhances the bioavailability of the active ingredient to the pest with targeted delivery and controlled release.According to structure and morphology of the nano system, nano pesticides can be divided into various types such as nano capsules, nanospheres, nanomicelles, nanogels, nanoemulsions, nanofibers, nanoliposomes etc. (Balaure*et al.*, 2017).Nano-silica particles seems to enhance tomato plants in controlling the cotton leaf worm, *Spodopteralittoralis*; this control tactic increased the yield. (El-bendary and El-Helaly, 2013).

Nano herbicides control weeds effectively through sustained release and enhanced herbicidal activity. They also eliminate adverse environmental effects by reduced leaching as well as negative effects on nontarget plants thus contribute to the improved level of safety in vegetable production.

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Nano fungicides and Nano bactericides:

Fungal diseases in vegetables causes major loss during production and storage resulting in reduced yields. Silver nanomaterials exhibited strong antifungal property by inactivation of fungal cell wall resulting in disruption of transmembrane and energy metabolism. Hence it can be used for raising healthy vegetable seedlings through enhanced seed germination and protection from several seed borne and soil borne fungi.

Nano devices for genetic engineering:

Nanoparticles mediated gene or DNA transfer in plants used for the development of resistant varieties (Saidaiah and Geetha, 2021).

Postharvest management:

Vegetables are highly perishable hence post-harvest management is important to increase shelf life and to maintain quality. Spraying of Nano-Cu (0.5ml/L) before the packaging prolong the shelf life. Nano biofilm and nanomaterial-based coatings are used to prevent the spoilage of vegetables after harvest as they have antioxidant and antimicrobial properties. Furthermore, it has also been demonstrated that combined nanomaterials with other preservation treatments can have a synergistic effect in prolonging shelf life of harvested products (Xu*et al*., 2017). Nano chitosan-based coatings avoid decay of cucumber and other vegetables.

Conclusions:

Nano technology is the advanced technology used to improve the productivity. Nano fertilizers increased the crop production and productivity through high nutrient use efficiency. They provide plant protection.Nanoparticles have several potential functions. The nanotechnology-based delivery of nanoparticles gives promising results for plant disease and pest resistance and enhanced plant growth with the help of controlled release formulations of nanoparticles and increasing the ability of plant to absorb nutrients.Nano sensors are used to diagnose disease, virus, nutrient content and hence can be utilized in precision farming of vegetables.

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