Popular article

NANOTECHNOLOGY AND ITS ROLE IN IMPROVEMENT OF CROP PRODUCTION FOR SUSTAINABLE AGRICULTURE

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Introduction

Agricultural field is always at utmost to feed the burgeoning population of human and animals. Over last decades agriculture gets constant benefits from different innovative technological and synthetic agrochemical like hybrid varieties, gene manipulation, synthetic fertilizers and pesticides. However, every agrochemical is not environmentally friendly and has risky factors pollution in water and food products which threat the environmental and human health, therefore the specific supervision could permit to diminish these dangers (Kour et al., 2020). Nanotechnology can handle the world's most problematic conditions such as water, energy, health, agriculture and biodiversity. Nanotechnology is the branch of science which deals with the particles of nano-meter (1–100 nm) dimensions. Because of their small size, they can simply enter in soil and assist beneficial microbial population that is responsible for providing nutrition to plants through mineralization of various micro and macronutrients (Agri et al., 2021). Among the many developments, nanotechnology has been proved as one of the advanced technologies that can resuscitate the agriculture and food demands. Morphology, type of functional group presents, coating and concentration of NPs influence their absorption by plants. Nanoparticles (NPs) cover a variable array of materials and play dynamic role in crop growth. Different plant varieties acted contrarily to similar kind of NPs of diverse size and concentration. Earlier, it has been detected that NPs can increase the agronomical, biochemical parameters in different plants such as maize and beans. Applications of nanopesticides and nanofertilizers can help enhance the productivity without causing any toxic effect on soil.

Importance of NPs: Nano fertilizers are known as keen fertilizer which is supplemented with either single or multiple nutrients, support the growth and plant development more efficiently than conventional fertilizer. Nano fertilizers contains plenty amount of nutrients in the form of nano zinc, silica, iron and titanium dioxide, gold nanorods, chitosan, zeolites, nanophos and clay minerals (Chaudhary et al., 2021). Better solubility of urea and monoammonium phosphate

coated with zinc oxide NPs are observed with better performance. Application of phosphorus based nanofertilizers improved growth and yield of soybean. Nanopesticides showed slow deprivation and precise release of active constituents, which may be an effective pest control remedy over long time duration because these can be transported in dissolved and colloidal state to increase their efficiency. Additionally, nano-pesticides are eco-and environmentally safe as it enhances efficacy and crop yields and lower input costs by reducing waste and labour costs. In modern agriculture, the applications of nanosensors involved in monitoring of physiological changes in plants such as early and rapid detection of pathogen, measure pressure and mass, gas concentration, nutrient estimation and biomolecular process. Recent studies reported that engineered nanomaterials can reduce the fertilizer requirement in fields, with improved efficiency and limited release into the environment. NPs of silver, carbon, silica, copper and alumino-silicates have been reported as potential antifungal agents and widely studied and reported to inhibit various plant pathogens and enhance seed germination and seedling weight.

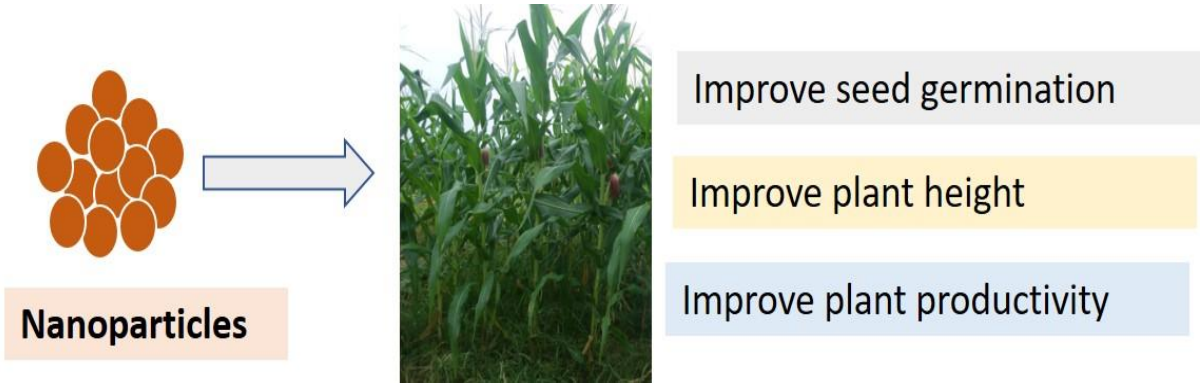

Fig. 1: Role of NPs in plant health improvement

Examples of NPs used in agriculture for crop production: There are various NPs which are applied in agricultural field to improve the growth of plants and their productivity in different crops.

Silver NPs: Application of silver NPs improved the photosynthetic efficacy and antioxidant system in wheat and fenugreek plants and also improved the root and shoot length as well as the enhancement in the phytochemical diosgenin.

Nanochitosan: This NPs improved the seed germination and protects pearl millet from mildew disease and also enhanced the expression of pathogenesis related proteins.

Nanozeolite: Zeolite's compound is made up of alumina-silicate and have various application in environmental and agricultural sector. This NP improved the productivity and soil health parameters of maize and fenugreek crop under pot and field conditions (Kumari et al., 2020).

Nanogypsum: Gypsum is an essential nutrient and available in soluble calcium and sulphur form. It improves the physiochemical properties of soil, improves availability of water, makes soil fertile and enhanced plant growth parameters.

Titanium dioxide (TiO_2): Beneficial impact of TiO_2 has been observed in plant development under salinity stress conditions which enhanced the production of antioxidant enzymes and amino acids which protect plants from stress conditions.

Copper NPs: Copper is an essential element and performs diverse metabolic functions in plants such as mitochondrial respiration, electron transport, and hormone signalling. Positive effect of CuO NPs was observed on vegetable crops such as lettuce and carrot where this is responsible for induce changes in root morphology by increasing the root thickness in lettuce.

Iron oxide NPs: This NP has beneficiary impact in *Citrus maxima* and *Helianthus annus* plant and improves seed germination. Positive impact of FeO_3NPs observed in ginger roots and an increase the protein levels and iron content of rhizome.

Zinc oxide NPs: Zinc is a vital micronutrient involved in the plant growth development process and functioning of various enzymes in plant cell. It was reported that ZnO NPs induces the production of ROS and antioxidant enzyme activities in wheat crop.

Conclusion

Agricultural production requires consolidative approaches to meet rising burden of food demand. Nanotechnology has confirmed well-built future to support plant growth and protection towards biotic/abiotic stresses. Application of nanofertilizers and nanopesticdes improved the plant health parameters, crop productivity and protects from plant pathogens. NPs can be applied in different crops and can be a well alternative to agrochemicals in agriculture field.

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