AgriCos e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 03 Issue:04 April 2022 Article No: 08

Novel Approaches of Nanotechnology Applications in Precision Farming

Srikanth G.A., Abhishek, S.K., Chiranjeevi C.M., and Arpitha H.K.
Assistant Professor, Department of Plant Physiology, Sampoorna International Institute of Agricultural Science and Horticultural Technology, Belekere, Channapatna, Karnataka

SUMMARY

Nanotechnology is a subject that spans many disciplines. Agricultural productivity has recently been boosted owing to intensive nanotechnology research. Pesticides and artificial fertilisers were used indiscriminately throughout the green revolution, resulting in the loss of soil biodiversity and the development of pathogen and insect resistance. Nanoparticles or nanochips are the only way to carry resources to plants, and enhanced biosensors for precision farming. Nanoencapsulated fertilisers, insecticides, and herbicides help with the delayed and sustained release of nutrients and agrochemicals, resulting in precise dosage to the plants. Plant viral disease detection kits based on nanotechnology are also gaining popularity and are useful in detecting viral infections quickly and early. This article discusses the potential uses and benefits of nanotechnology in precision agriculture. Modern nanotechnology-based equipment and techniques have the ability to fix and improve a range of challenges in traditional agriculture.

INTRODUCTION

Nanotechnology has been applied in many sectors of study, including physics, chemistry, pharmaceutical science, material science, medicine, and agriculture. The encouraging achievements in other industries have opened up a lot of doors in agriculture as well. Precision agriculture, as per the European Union's Additional director for Underlying Policies, is an agricultural management approach that involves measuring and responding to inter and intra-field varying in crops in order to create a stance framework for whole farm management and to get the most out of the available resources.Nanotechnology is now widely used in modern agriculture to bring the concept of precision farming to life. Nanotechnology refers to nanoparticles with one or more dimensions of fewer than 100 nanometers. Because of their small size, high surface-to-volume ratio, and unique optical properties, nanomaterials have uses in plant protection, feeding, and farm management.Metal oxides, ceramics, magnetic materials, semiconductors, quantum dots, lipids, polymers (synthetic or natural), dendrimers, and emulsions are among the materials utilised to make nanoparticles. Pesticides are eaten in around two million tonnes per year around the world, with Europe accounting for 45 percent, the United States for 25%, and the rest of the world for 25%. Pesticide use that is careless and unplanned promotes disease and insect resistance, diminishes soil biodiversity, kills beneficial soil microbes, causes pesticide biomagnification, pollinator loss, and disrupts natural habitat of farmer allies like birds.

Nanotechnology has a huge range of possible applications and benefits. These include insect pest management with nanomaterial-based herbicides and insecticides, as well as increased agricultural output with nanoparticle-encapsulated fertilisers that release nutrients and water slowly and consistently. Some of the benefits of modern nanotechnology include nanoparticles mediated gene or DNA transfer in plants for the development of insect pest resistant varieties and the use of nanomaterials for the preparation of various types of biosensors that could be useful in remote sensing devices required for precision farming. Traditional agricultural solutions such as integrated pest management are insufficient, and the use of chemical pesticides has negative consequences for animals, beneficial soil bacteria, and soil fertility. To address this issue, new effective and non-persistent insecticides, such as controlled release formulations, must be developed. Micro fabrication and nanotechnology advances are now playing an important role in viral detection, lowering the detection limit, simplifying operations, and increasing the cost-effectiveness of viral diagnostics.

Importance of Nano fertilizers:

Delivery of fertilizers: Massive volumes of fertiliser in the form of ammonium salts, urea, and nitrate or phosphate compounds have significantly enhanced food production, but they have a number of negative impacts on the beneficial soil microflora. Because of run-off, most fertilisers are unavailable to plants, resulting in pollution. This problem can be solved by using fertilisers that have been coated with nanoparticles. Nanomaterials have the ability to aid in the gradual release of fertilisers since nanoparticles have a higher surface tension than ordinary surfaces and thus hold the material more tightly from the plant. Nanocoatings also shield bigger particles from the elements. A diagram depicting the distribution of insecticides, fungicides, and nutrients through nanocoatings.

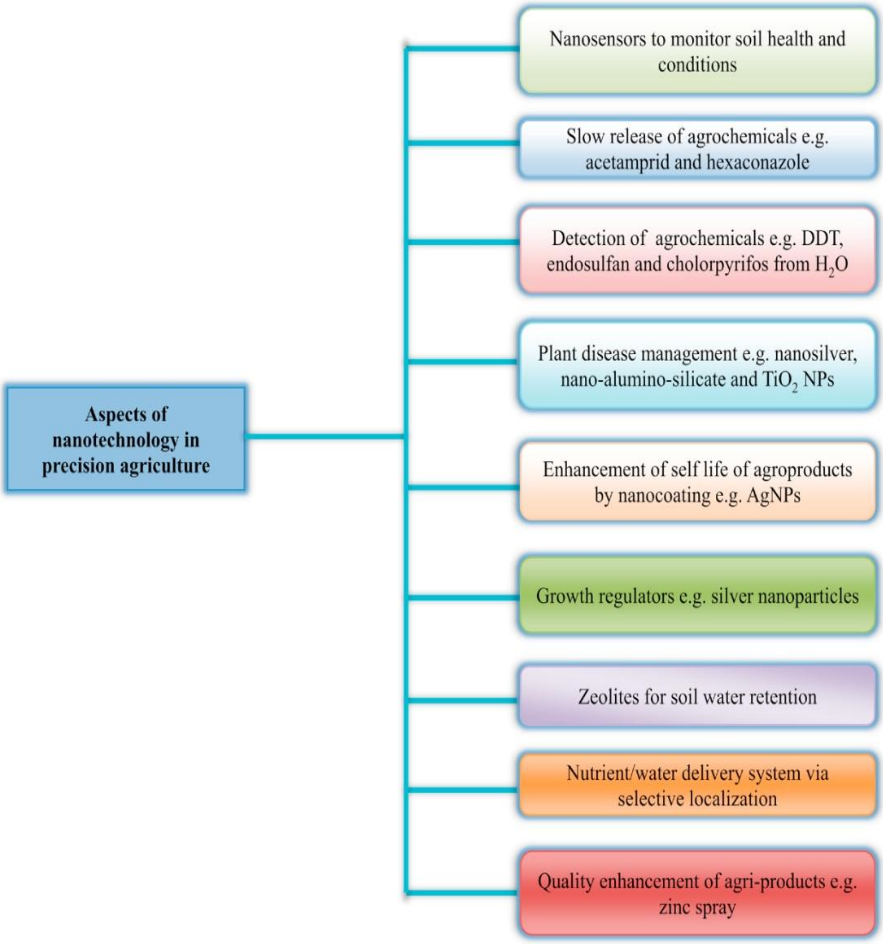

Fig: Applications of nanotechnology

Chemical fertilizers: Throughout India's green evolution phase, usage of nitrogen fertiliser in the form of urea increased by a factor of two (29 percent). Excess nitrogen application in agriculture is responsible for 80% of the rise in atmospheric N2O (a greenhouse gas) that causes higher atmospheric temperature and hence contributes to global warming. To compensate for the lack of N, P, and K in the soil, chemical fertilisers such as urea, di-ammonium phosphate (DAP), and single superphosphate (SSP) are used in agriculture.

The nanocoating's durability decreases the rate of fertiliser disintegration, allowing for a steady, sustained release of coated fertiliser that is more efficiently absorbed by plant roots. Slow release fertilisers have recently emerged as a novel way for reducing fertiliser consumption and thus reducing pollution. Slow release fertilisers with a sulphur nano-coating (100 nm layer) are effective because sulphur content is beneficial, especially insulfur-deficient soils.

Since the majority of soil in India is lacking in these macronutrients, particularly nitrogen, nanocoated urea and phosphate, as well as their sustained release, will be advantageous in meeting soil and crop demands. For this long-term release of fertilisers, a variety of natural and synthetic polymers have been utilised.

Nanofertilizers regulate the distribution of nitrogen and phosphorus fertilisers with plant absorption, reducing nutrient losses and undesirable nutrient interactions with microbes, water, and air. The use of nanofertilizer can help plants absorb more nutrients from the soil. After absorbing nutrients, nanofertilizer encapsulating nanosilica can create binaryfilms on the cell wall of fungus or bacteria, preventing infections and improving plant development under warm temperatures, as well as disease resistance.

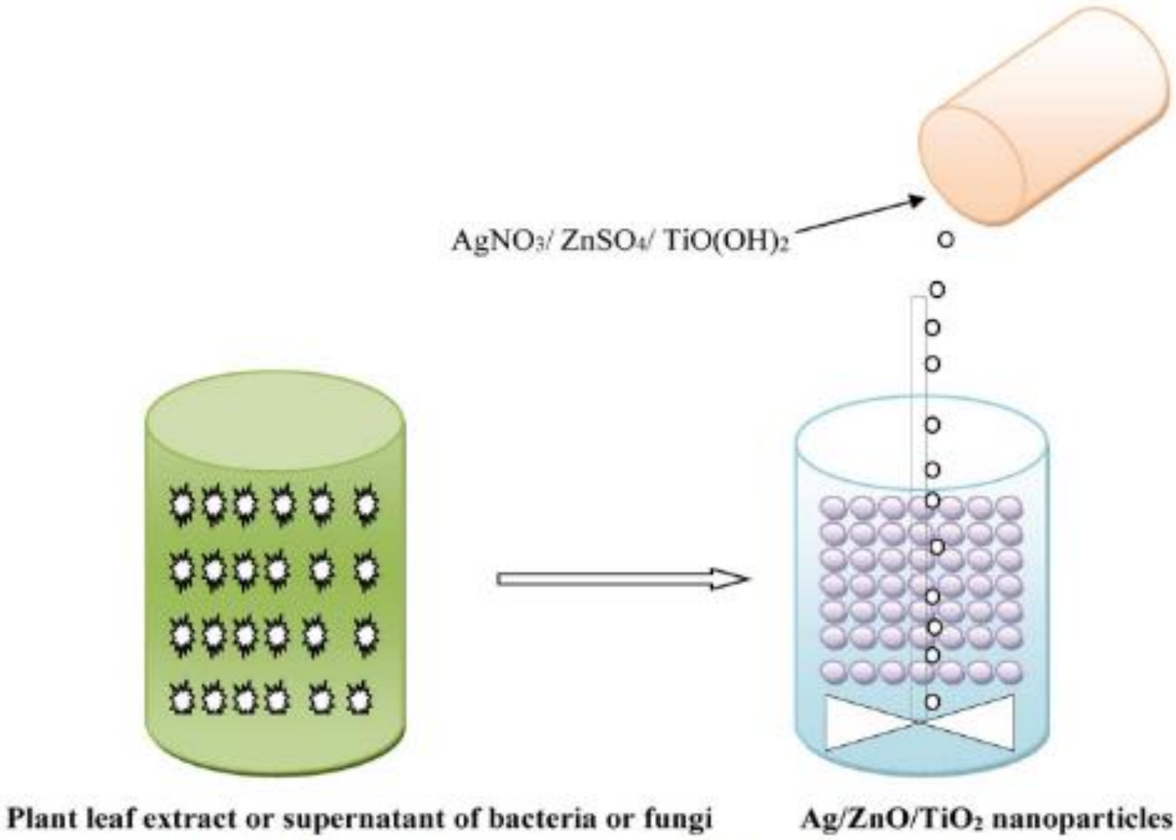

Fig. 1. Biological synthesis of silver/zinc oxide/titanium dioxide nanoparticles.

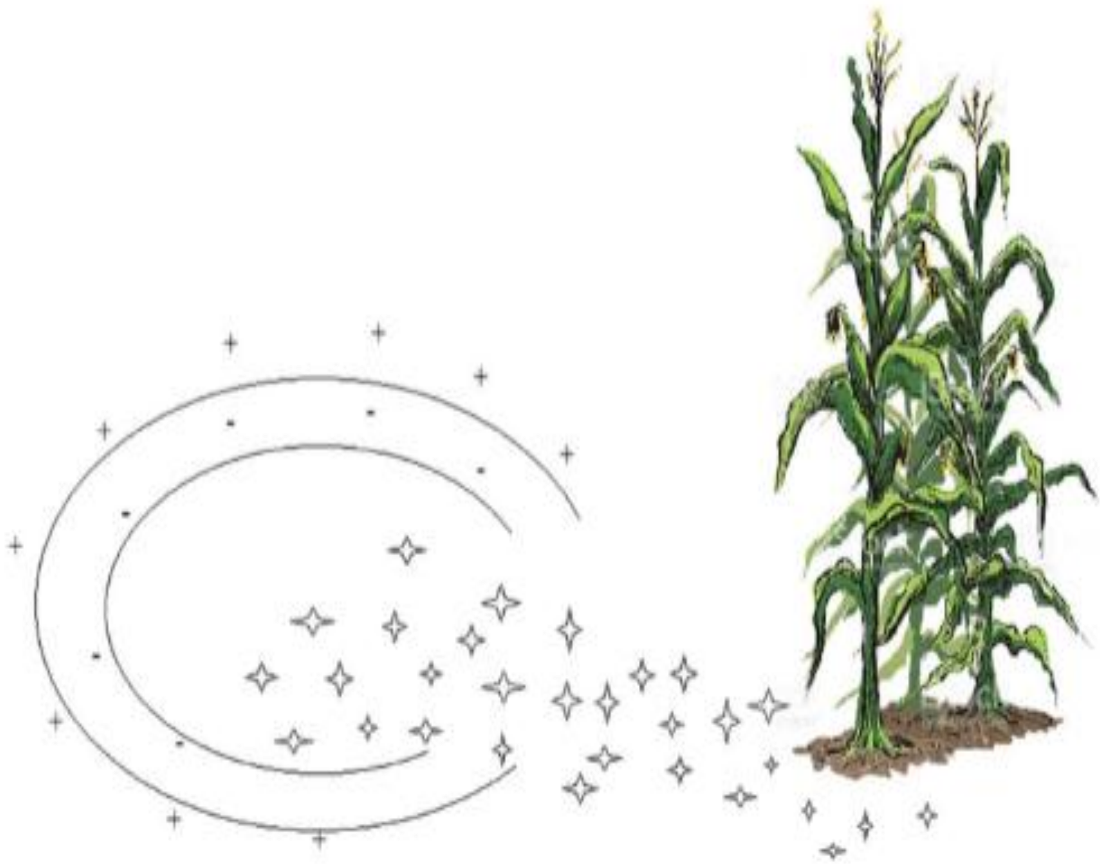

Fig. 2. Controlled release of pesticides/fungicides/nutrients from nanocoating.

Biosynthesis of nanoparticles and their use in agriculture

Because there are many chemical processes for synthesis of nanoparticles that involve harmful compounds, the need of the hour is to use environmentally benign, greener, and ecofriendly technologies. Researchers are looking for biological organisms that can reduce salts to matching nanoparticles, such as bacteria, fungi, related species, actinomycetes, and viruses, to synthesise nanoparticles. Nanoparticles have been synthesised from a variety of biological sources and are now being employed in agriculture for precision farming. Silver nanoparticles, zinc oxide nanoparticles, and titanium dioxide nanoparticles are a few examples.

Nanofertilizers and their action against plant pathogens.

Type	Nanofertilizers	Antimicrobial action against plant pathogens
Plant growth promoting microorganisms	Ag	*Bacillus cereus*
	Ag	*Escherichia coli, Bacillus subtilis* and *Streptococcus thermophilus*
	Ag and TiO_2	*Lactobacillus strains*
	Ag	*Corynebacterium* sp.
	Au	*Klebsiella pneumoniae*
	Ag	*Fusarium oxysporium*
	Ag	*Aspergillus fumigatus*

Biosensors in precision agriculture

Precision farming is a long-awaited goal that aims to optimise crop output while reducing fertiliser, pesticide, and herbicide use by monitoring environmental variables and taking targeted action. Precision farming use computers, sensors, global satellite positioning systems, and remote sensing devices to evaluate highly localised environmental variables and aid in detecting if crops are growing at their peak efficiency or precisely pinpointing the nature and location of problems. Finally, precision farming using smart sensors would increase agricultural productivity by providing correct data and assisting farmers in making better decisions.

CONCLUSION

Precision agriculture has showed significant promise thanks to nanotechnology. Nanoparticles with distinct features can be easily made from a variety of biological sources and used in agriculture. Plant extracts (leaves, flowers, stems, and roots) from a wide range of plant species have been utilised to successfully synthesise nanoparticles. In a single-step green manufacturing process, biomolecules found in plant extracts convert metal ions to nanoparticles. This green synthesis process is eco-friendly, simple to carry out, can be done at room temperature without the use of a specialised instrument, and can simply be scaled up or adjusted to meet the needs. Various water soluble plant metabolites (such as alkaloids, phenolic compounds, and terpenoids) and co-enzymes are converted to nanoparticles in this process.Through the use of controlled release nanoparticle formulations, nanotechnology-based distribution of nanoparticles has shown promising outcomes for plant disease resistance, increased plant growth, and nutrition via site specific delivery of fertilisers and other critical nutrients. Herbicide application can also be improved by using nanoencapsulation, which allows for better penetration and a delayed and sustained release of the active ingredients. As a result, nanotechnology can provide a green, efficient, and environmentally friendly solution for managing insect pests in agriculture. In the coming times of agricultural mechanisation, new nanotechnologies tools and processes can enhance the way agriculture is seen and has a promising future. Nanoparticles have a lot of potential as "magic bullets" that can be loaded with herbicides, fungicides, nutrients, fertilisers, or nucleic acids and targeted to specific plant tissues, releasing their charge to the chosen section of the plant to accomplish the desired results. Precision delivery of nutrients and fertilisers, as well as disease diagnosis at an early stage, have a bright future thanks to biotechnological advancements and the use of nanomaterials to create faster and more precise diagnosis instruments.

REFERENCES

Ali, S.M. Yousef, N.M.H. Nafady, N.A. 2015. Application of biosynthesized silver nanoparticles for the control of land snail Eobania vermiculata and some plant pathogenic fungi, J. Nanomater.

Auffan, M. Rose, J. Bottero, J.Y. Lowry, G.V. Jolivet, J.P. Wiesner, M.R. 2009. Towards a definition of inorganic nanoparticles from an environmental, health and safety perspective, Nat. Nanotechnol. 4 (1) 634–664.

Bose, A. D., Kumar, A. and Mozumdar, S. 2014. Worldwide pesticide use, in: A. De, R. Bose, A. Kumar, S. Mozumdar (Eds.), Targeted Delivery of Pesticides Using Biodegradable Polymeric Nanoparticles, Springer, India, 2014, pp. 5–6.

Ghormade, V. Deshpande, M.V. and Paknikar, K.M. 2008. Perspectives for nano-biotechnology enabled protection and nutrition of plants, Biotechnol. Adv. 29 (1) 792–803.

Mishra, S. Singh, B.R. Singh, A. Keswani, C. Naqvi, A.H. and Singh, H.B. 2014. Biofabricated silver nanoparticles act as a strong fungicide against Bipolaris sorokiniana causing spot blotch disease in wheat, PLoS One 9 (2014) e97881.

Puoci, F. Lemma, F. Spizzirri, U.G. Cirillo, G. Curcio, and M. Picci, N. 2008. Polymer in agriculture: a review, Am. J. Agri. Biol. Sci. 3:299–314.

Ragaei, M. and Sabry, A.H. 2014. Nanotechnology for insect pest control, Int. J. Sci. Environ. Technol. 3 (1) 528–545.

Rai, M. and Ingle, A. 2012. Role of nanotechnology in agriculture with special reference to management of insect pests, Appl. Microbiol. Biotechnol. 94 (2012) 287–293.

Tilman, D. Cassman, K.G. Matson, P.A. Naylor, R. Polasky, S. 2002. Agricultural sustainability and intensive production practices, Nature 418 (2) 671–677.

Zheng, L. Hong, Liu, F. and Lu, S.C. 2005. Effect of nano-TiO (2) on strength of naturally aged seeds and growth of spinach, Biol. Trace Elem. Res. 104 (2) 83–91.