

Nanotechnology: A New Role Player in Crop Improvement

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Introduction:

Nanotechnology is a new emerging technology nowadays due tiny size of particles and effective working. Nanotechnology can become a new and efficient technology in the field of agriculture and especially crop improvement due to its efficiency of fast and easy delivery of genes and the mode of action of partials that leads to changes of action of genes.

Nanotechnology is a Greek word which means too small. Nano size is 10^{-9} m in comparison with a meter and the size of nanoparticle ranges from 1 to 100 nm which has one or more dimensions. The idea of nanotechnology given by Richard Feynman in the popular sentence “There's Plenty of Room at the Bottom” led to some pioneer ideas in this field. The idea for the development of molecular nanotechnology was given by K. Eric Drexler.

Modes of application of nanoparticles in plants:

Nanoparticle application is done by two approaches (1.) Traditional, and (2.) Modern

Traditional approach:

1. **Direct incubation:** nanoparticles are directly added through seed, pollen and seedling by incubation of this with nanoparticles.
2. **Direct injection:** nanoparticles are directly injected into the plant parts through the needle.
3. **Spraying:** spraying of particles onto the plant parts.
4. **Hydroculture:** add particles into the hydroculture (hydroponic) media which are absorbed by plants and in this way, particles enter into the plant parts.

Modern approach:

1. **Biolistic:** nano particles are added to plant tissue by a speed gun (gene gun).

2. **Cell/ protoplast incubation:** nanoparticles are incubated with cell or protoplast culture for some time.

Nanoparticles are added to the plant system through various applications and are moved in the plant through the plant vascular system. Nanoparticle which contains genetic material (RNA, DNA or protein) delivered in a specific place either nucleus or organelle-specific delivery.

Application of nanoparticles in the agriculture sector:

- ✚ **Nonosensors and nano tracers:** this nanodevice are used the monitor plant growth disease, soil quality, pest attacks and irrigation management.
- ✚ **Fertilizer delivery:** Nano fertilizer is now a day available in the market which has a high fertilizer use efficiency. Which can reduce the fertilizer loss done through the leaching and running. Which leads to an efficient reduction of agrochemical usage.

Nanoparticle for alteration of gene action through various applications:

- ✚ **Phytomedicine enhancement:** nanoparticle application improves the medicinal drug content present in the plant like improvement in the anticancer and antidiabetic drug in the plant through the application of the nanoparticles.
- ✚ **Enhancement in secondary metabolite** content present in the plant like an increase in the concentration of aloin, hypericin, artemisinin etc.
- ✚ **Plant disease management:** some particles have anti-microbial activity which can suppress the plant disease directly through application onto the plant like, Ag, Si, ZnO, Mg, and TiO₂.

Nanotechnology for crop improvement:

For crop improvement, nanotechnology has two types of approach

- ✚ Gene alteration through various applications of nanoparticles
- ✚ Gene transformation through the nanoparticles (GMO)

Gene alteration through nanoparticles for crop improvement

Alteration done for the various traits

1. **Agronomic traits:** Nanoparticle application can improve agronomic traits in which improvement vegetative traits like increasing germination index, root/shoot biomass, root elongation and reproductive traits like improved number, size and biomass of flowers and fruits and found to increase seed setting rate in plants.

2. **Qualitative traits:** Nanoparticle application can also improve qualitative traits like protein, carbohydrate, lipid and other biomolecules.
3. **Physiological traits:** Nanoparticle application can improve the photosynthetic machinery via improving the pigment content, enhanced RuBisCo activity, and improving stomatal conductance.

Ultimately by improving those traits in plants that affect the yield, the yield of plants will be increased.

Gene transformation through nanoparticles

Need for newer technology for gene transformation

- ✚ For gene transformation, the most used approaches are biological method, chemical and physical transformation, but these methods have some limitations,
- ✚ For biological transformation agrobacterium-mediated gene transformation is most widely used in which can use in only on those plants which can produce acetosyringone, and also in most time the super facial DNA of the bacterium also integrated with plant genomic DNA which can cause some deleterious effects in the plant genome.
- ✚ For chemical transformation, different types of polymers are used which can cause toxicity in plant tissues.
- ✚ In the physical method particle bombardment is widely used in which a gene is entered into the plant speed gun, The speed of the molecule can cause damage in targeted tissues, and it also leads to random integration of the gene in any tissue.

Due to this critical drawback of the conventional plant transformation method we need to find a new solution for plant transformation or to make the GMO. Nanotechnology has the potential to become a new and efficient technology in plant transformation because nanoparticles are promising tools as they allow for species-independent passive delivery of biomolecules (DNA, RNA, and Proteins).

Nanobiotechnology techniques have improved the precision of plant breeding by generating exciting new possibilities for gene selection and transition, reducing the time required to remove unwanted genes. Carbon nanotubes (CNTs) can carry RNA and DNA, while, metallic NPs can only deliver DNA as genetic material. Silicon-based NPs can carry DNA and proteins, whereas polymeric NPs can transfer encapsulated RNA, DNA, and proteins into cells. Also, some different nanoparticles like chitosan, magnetic nanoparticles, silica

nanoparticles, ZnO, Calcium phosphate etc. mostly used for the gene transformation into plants by using applications discussed before.

Gene transformation using nanoparticles increases the speed of the process as it doesn't need regeneration of transformed plant via tissue culture as a must step because of direct application availability. It is also helpful for gene transfer in those plants which are tissue culture recalcitrant.

Conclusion:

Due to the unique features of nanoparticles, they have been used in all stages of agricultural production. Nanotechnology is a new and efficient technology for gene manipulation and gene transfer.

