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Opinion

Potential Applications of Nanoparticles on the Growth and Physio-chemical Attributes of Plants

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The famous quotation by the American scientist Richard Feynman "There is plenty of room at the bottom", provided new opportunities and possibilities for the research and development at the Nano scale. Nanotechnology is basically the design of products at the molecular or atomic level which creates functional materials from atomic particles. Within the different platforms of nanotechnology, research in chemistry and biology has revealed novel insights into molecular and cellular dimensions at nanometric level [1]. The overall perception in these emerging research fields lies in the fact that nanotechnology can offer biology new tools to understand the complex biological processes in depth.

The ultimate products of nanotechnology i.e. Nanoparticles (NPs) have got much attention due to their novel and significant applications in the fields of plant sciences, biotechnology and agriculture. Due to the unique physicochemical properties of Nanoparticles (NPs) for instance, particle morphology, higher reactivity and surface area and confined pore size, they can serve as "Magic Bullets" for solution to the various existing problems in terms of low yield of crops, pest manifestations, soil erosion and low activity of fertilizers in the soil [2]. Nano structures which can harbor efficient delivery system for herbicides, pesticides, fertilizers or specific genes for targeting specific cellular process for overcoming the mentioned problems (Figure 1 and Figure 2).

Nanotechnology provides substantial opportunities for the scientists working in Plant sciences and Agricultural biotechnology to develop and adopt new methods and tools for applications of Nanoparticles (NPs) into commercially important plants and crops. This might improve the existing functions and will also add novel features and traits. Nanotechnology contributes further, new ideas that may lead us to understand the suitable mode of action of nanoparticles in plants. It is important to elucidate appropriately the physiological, biochemical, and molecular mechanism of nanoparticles in plant for better plant growth and development [4].

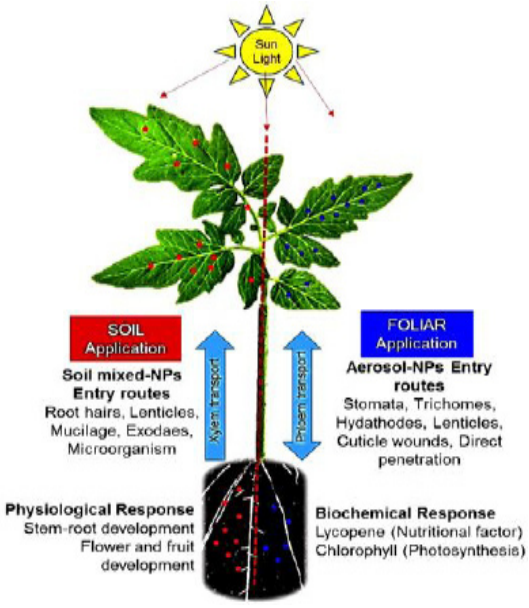

Figure 1: Effects of Nano Nutrients an A Physiological & Biochemical Attributes of Tomato Plant [3].

Applications of Agrofertilizers are diverse and are of significant importance for plant growth and development. However, many of the commercially available fertilizers are at the pose to low efficacy due to multiple factors for instance, the rendered unavailability to plants, leaching, photolytic and hydrolytic degradation and decomposition. Nevertheless, it is vital to minimize and control nutrient losses and to increase the crop yield through the exploitation of magnificent nanomaterial and nanoparticles. Encapsulation of nutrients through nanomaterial may be used as Nano-fertilizers which might have essential properties that are effective to crops and can control the release of chemicals fertilizers that may eventually regulate plant growth and development [5].

Higher plants, having more plasticity can adopt to varying environmental conditions. They can develop different coping

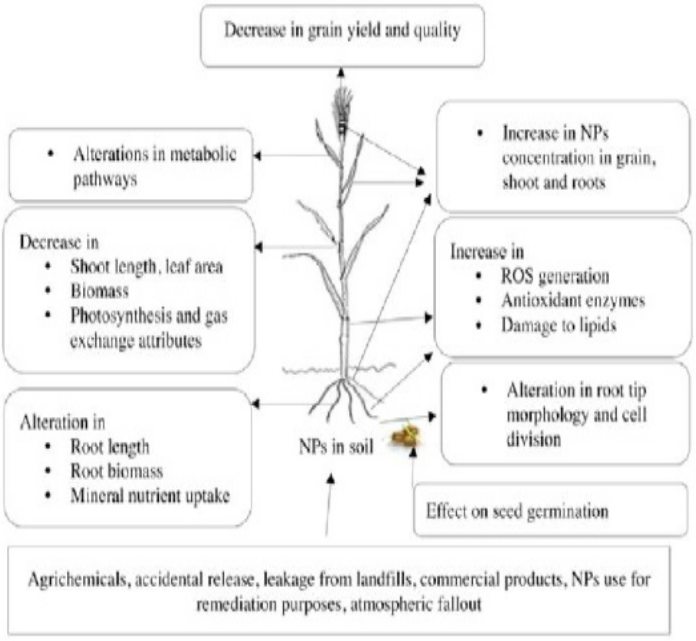

Figure 2: Applications of NPs for Remediation and Atmospheric Fallout [4].

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Higher plants, having more plasticity can adopt to varying environmental conditions. They can develop different coping mechanisms to perform better both under favorable and non-favorable conditions. Researchers are now thinking and trying to opt for the new techniques and methods that can be used to augment and boost the native functions of important plants and crops [3].

A variety of NPs have been synthesized recently, that can be used to boost and tailor the plant metabolism and biochemical attributes. Nanoparticles have been engineered in order to enter the plant system and transport desired DNA and chemicals into targeted plant cells. This area of research links nanotechnology with biotechnology and offers an interface for new possibilities in the field of plant biotechnology to transfer specific gene into the plant cell, as well as its manipulation, regulation and expression [6].

Plants with more photosynthetic activity are advantageous for production of yield (biomass) and nutritive characteristics. Recently, Carbon Nanotubes (CNTs) have successfully delivered into the chloroplast to enhance plants' ability to harvest more light energy. CNTs could serve further as artificial antennae to manipulate chloroplast for capturing light in the wavelengths of light, not present in the normal range, such as green, ultraviolet and infrared. Besides for their potential to capture and harvest maximum solar energy by plant cell, CNTs have also reported for their pivotal role in seed germination and plantlet growth and development.

The engineered carbon nanotubes also boost seed germination, growth, and development of plants. Multi Walled Carbon Nanotubes (MWCNTs) a type of the engineered CNTs may regulate expression of specific genes that encode different types of water channel proteins in soybean, corn and barley seeds coat. They have an essential role in up regulating some important marker genes for cell division, cell wall formation, and water transport during cell cultures of tobacco [7].

Many physiochemical parameters which are of prime importance for attaining normal growth and development of plants like net photosynthetic rate, stomata conductance, electron transport rate, photochemical efficiency, gas exchange and chlorophyll parameters were enhanced by application of Nano-SiO2.

NPs of Titanium Dioxide (TiO2NPs) have role of enzymatic regulation during nitrogen metabolism and augmenting plant cell for increase light absorbance, transport and conversion of the light energy, protection of chloroplasts from aging, and enhancing the photosynthetic time of the chloroplasts.

The anticipated reason for the protective role of TiO2NPs in the chloroplast might be the activations of antioxidant enzymes by these NPS, for instance Catalase (CAT), Peroxidase (POD) and Superoxide Dismutase (SOD).

Silver Nano particles (AgNPs) have reported to induce genes expression involved in different cellular events such as protein synthesis of cell-division-cycle kinase 2, protochlorophyllide oxidoreductase, and fructose-1,6 bisphosphate aldolase. AgNPs are suggested to act as inhibitors of ethylene perception and could manipulate ethylene biosynthesis.

Gold Nanoparticles (AuNPs) have recently been used as efficient carriers of phosphotransferase II gene into soybean genome. They are further reported to have a significant role on seed germination and antioxidant system in Arabidopsis thaliana and altered levels of microRNAs expression that regulates various morphological, physiological, and metabolic processes in plants [2].

A very common issue in using these multi-potent NPs in many plant biotechnological interventions is the toxicity of NPs to plant system when applied at higher levels. However more studies should be conducted to determine the optimal levels of NPs at which plant cell has best growth and development. Moreover, the physiological and molecular mechanisms, by which NPs exert their effect on plant growth and development should be elucidated. It is worth mentioning here that the effect of NPs on plants varies from plant to plant, their growth stages, and the nature of nanoparticles. Moreover, recently biogenic NPs have been reported as more efficient in plants growth and development than chemically synthesized NPs.

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