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NANOMATERIALS AN EFFECTIVE TOOL TO INDUCE ANTIOXIDATIVE SYSTEM IN THE PLANTS

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Abstract: The concentration of free radical scavenger in the cell regulates the oxidative stress caused by various external and internal factors. The application of these antioxidants having the maximum surface area control the production of free radical efficiently in the cell. The production and removal of free radicals in the cell balanced when the antioxidative activity and content of non enzymatic antioxidants exceeds in the cell. The content of antioxidants becomes lower when stress is sustain for a long time. The size and structure of antioxidants regulate their movement in the cell as well as determine the surface area for covering the stress site. However antioxidants in the form of nanoparticle able to enter and penetrate the maximum area of cell in the stress site and effectively control the production of free radicals and cascade of chain reaction caused by free radicals in the membrane. Addtionally, the antioxidants *viz.* Ascorbic acid, Carotenoids, Tocopherol, Glutathione, Phenolics (Ferulic acid, Gallic acid, Coumaric acid, quinic acid, syringic acid), Flavonoids, Flavonol, Anthocynin, Zinc, Selenium, etc. in the form of nanoparticle, encapsulations, hollow particles, nanogels etc. might provide the improved stability, biocompatibility and coverage of maximum surface area in the targeted cells/tissues. Thus, application of antioxidants in the form of nanomaterials improves the antioxidative capacity of the cell and reduces the stress in the plants.
Keywords: Antioxidants, Free radicals, Nanoparticle, Plants, Stress.

Introduction

Free radicals in the cell acts as initiator of signaling process in many cases of metabolism but in chloroplast and mitochondria affects the photosynthesis and respiration and these are considered as harmful molecule that are by product of metabolism of oxygen. In controlled production these free radicals act as signaling intermediates in stomatal regulation, growth and developmental processes, drought, salinity, temperature extremes, high light, nutrient imbalance, or heavy metal toxicity disturb redox homeostasis and other stress response (Soares et al., 2019). But production of these radicals exceeds leading to cellular damage, affecting lipids, proteins, and nucleic acids. Excess free radical in the system causes several disorders and eventually in uncontrolled state led to permanent damage to the plants. Non Enzymatic antioxidants are the essential for defense and development of the plants. They suppressed reactive oxygen or nitrogen species produced at the cellular level and minimize

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the damage of different cellular structures and consequently the integrity of the entire plant (Li et al., 2023). The metabolites which are capable of scavenging the ROS non-specifically are most important in the system for minimizing the adverse effects of free radicals produced during the stress. These metabolites are known as non-enzymatic antioxidants and they have the capacity to neutralize a variety of reactive oxygen species. Hence, in the living system particularly plants which suffers from different type of stress day by day it is necessary to maintain sufficient antioxidant production to suppress the production of reactive oxygen species (Jiyang et al., 2021). The application of different antioxidants either internally or externally is not effective to control the excess free radical. The nanomaterials are the right choice to carry the antioxidants and able to enter and penetrate the maximum area of cell in the stress site and effectively control the production of free radicals and cascade of chain reaction caused by free radicals in the membrane (Ahmed et al., 2021).

Antioxidants and their Nanoparticles carrier

Biogenic generated different kinds of nanoparticles have greater impacts on metabolic system as well as ecosystem than synthetic nanomaterials. Plant metabolic system response well in presence of nanomaterials than macro or micro materials. It facilitates the better permeability as well as covering maximum surface area for performing the activities (Alabdallah et al., 2021). Its effectiveness depends on the size of particle, surface charge, morphological feature, chemical constituents, etc. Higher Surface-to-volume ratio in smaller dimensions nanomaterials provide increased surface area for exposure of more atoms and interaction with surrounding biomolecules, cells, or environmental components. The other characteristics of nanomaterails are quantum effects associated with their higher surface area. This trait facilitates accelerated reaction kinetics, stronger catalytic activity, and increased potential. The distinctive size-dependent behaviors associated with quantum effects varies 1-100 nm depending upon the target materials as well as selected nanomaterials (Khan et al., 2020). It can modify electronic and magnetic properties; enabling behaviors in certain elements that are absent in their bulk components. The biological membranes are negative in nature hence nanomaterials cause toxicity by strongly binding to negatively charged membranes. This strong binding results in interference in normal cellular functions and disrupt the metabolism. Thus nanoparticles designed with negatively charged ligands for minimizing the surface association and toxicity (Giraldo et al., 2019).

Nano-antioxidants

Nanoparticles synthesis from biological natural resource has been developed by Green technology that produces nanomaterials with cheap, clean, ethically sound and marketable. They behaves like enzymes and considered as nano antioxidants with size varying from 1 - 100 nm (Kumar et al., 2019). Metal based nanoparticles have inherent properties for redox activity which enable them in free radical scavenging and act like enzymatic antioxidants. The zinc oxide nanoparticles is the most widely used metal oxide nanoparticles due to their little toxicity, biocompatibility and affordability. The production of zinc oxide nanoparticles through Pseudomonas aeruginosa rhamnolipids and their antioxidant capability are the successful approach to combat chemical hazard and pollution (Chen, H., 2018). Copper Oxide Nanoparticles produced through biological approach by using bacteria, fungus, yeast, algae, and plants. These nanoparticles were very effective in scavenging of free radicals during stress in plants (Van Nguyen et al., 2021). Iron oxide nanoparticles were synthesized by aqueous extracts from *Amaranthus spinosus* leaves reduced with ferric chloride. The another nanoparticles Cobalt ferrite applied in industrial purposes, energy devices, biotechnological reseach and pharmaceutical industries. These are applied in different purposes such as food preservation, bioprocess intensification, bioseparation, antioxidant and antibacterial applications, medication delivery and magnetic targeting (Adrees et al., 2020). Gold nanoparticles are costly but frequently used due to their special optical and physical features that enable them to take surface plasmon oscillations for imaging, sensing and labeling (Vakilian, K.A., 2019). Phosphonate derivatives nanoparticles synthesized by using 2,4-dihydroxyacetophenone, isopropenylacetylene, 2-amino-N-alkyl benzamide, dialkyl acetylenedicarboxylates, and trimethyl phosphite in the presence of reusable ZnO/Fe_3O_4 nanocomposites have been considered as very efficient in targeted delivery. Silver nanoparticles (AgNPs) applied in different purposes in pharmaceutical, agricultural, antimicrobial agents, imaging probes, and diagnostic and optoelectronic platforms. Their wide range of application these are the most preferred nanoparticles in biomedical, therapeutical and agricultural applications (Elsakhawy et al., 2018)

Conclusion

The application of antioxidants in plants through nanomaterials efficiently reduce the oxidative stress. The biogenic nanoparticles are more preferred in agricultural field for sustainable production and healthy ecosystem.

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