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Citric Acid/ β-Alanine Carbon Dot Mediated Functional DNA Delivery in Plants.

Currently, agriculture and food security face significant challenges due to population growth, climate change, and urbanization. These factors place enormous pressure on global food systems, necessitating urgent advancements in biotechnology to address various issues, such as improving crop yield, quality and reducing losses caused by biotic and abiotic stresses. To meet demands, biotechnology is pivotal for enhancing crop yield, quality, and resilience against stresses. Particularly, genome editing, particularly, has bolstered crop stress resistance, yet transforming certain plant species remains challenging due to cell wall barriers. In recent years, researchers have been exploring the use of nanoparticles, known for effectively delivering drugs to animals, to address challenges in plant science. This innovative approach holds promise for advancing our understanding of plants and enhancing their capabilities. In this study, we evaluated the efficacy of citric acid/β-alanine carbon dots as a vehicle for biomolecule delivery in different plant tissues. Initially, carbon dots (CDs) were synthesized using a microwave-assisted technique. These produced carbon dots possess essential functional groups crucial for interacting with DNA, such as keto, nitrile, and carbonyl groups. The interaction between DNA and CDs was assessed using gel electrophoresis. Then we demonstrated the efficient delivery of functional plasmids of different sizes, such as sGFP (4kb), dsRED (11kb), and pTSU-GFP (17kb), into onion epidermal cells and efficient delivery of gus gene into soybean cotyledons using biolistic DNA delivery method. Additionally, CDs showed efficiency in delivering functional plasmids with the reporter gene GUS into canola seeds and soybean roots using vacuum infiltration and root dip methods, respectively. These findings highlight the potential of CDs as promising tools for enhancing agricultural biotechnology, offering sustainable solutions for crop improvement and global food security. Future research endeavors aim to explore the potential of CDs in delivering CRISPR constructs into plant cells to advance plant genetic engineering further.