From Hair to Harvest: Effects of Nitrogen-Doped Carbon Dots on Germination and Growth in Solanum lycopersicum (Tomatoes) Seedlings Using Keratin-Based Hydroponic Substrates

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Hydroponic systems are an efficient method of plant cultivation that is gaining popularity due to its high yields and resource efficiency. However, current hydroponic substrates like mineral wool and phenolic foam are non-biodegradable and pose potential health risks, raising sustainability concerns. A biodegradable alternative to these substrates that has been developed recently is keratin-based substrates derived from human hair and food waste. Incorporating nutrient-doped carbon dots (CDs), particularly nitrogen-doped CDs (N-CDs), into these substrates could enhance plant growth by improving nutrient availability. This study aims to assess the impact of N-CDs on the wet above- ground biomass, shoot length, and root length of Solanum lycopersicum seedlings grown in keratin-based hydroponic substrates. Tomato seedlings were grown in keratin substrates with N-CDs, Cu-CDs (the previously best-performing additive), and no CDs, with wet above-ground biomass, shoot length, and root length measured to determine the impact of nitrogen addition. Results indicated that N-CDs significantly reduced root length compared to Cu-CDs, with a 50% shorter root length on average. No significant difference was observed in above-ground biomass or shoot length, suggesting the substrate already provided sufficient nitrogen. These findings suggest that excess nitrogen from N- CDs in combination with keratin release from the substrate may hinder root development in this substrate. Further research on optimizing nutrient levels in keratin-based substrates is needed to improve its potential as a biodegradable, waste-derived solution for hydroponic farming.

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