**DOPED CARBON QUANTUM DOTS AND THEIR APPLICATIONS ON PLANTS UNDER STRESS CONDITIONS; A REVIEW**

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**ABSTRACT**:

Carbon dots (CDs), a novel member of the renowned carbon-based nano-materials family, have gained tremendous attention in various fields especially in plant sciences. Carbon Quantum Dots (CQDs) can be synthesized by various methods, including chemical and green approaches, and using different types of elements as dopants such as nitrogen, phosphorus, sulfur, cerium, and metal oxides. CQDs interact with plants, including their uptake, translocation mechanisms, and impacting plant’s physical, physiological and genetic parameters under various stress conditions, including drought, heat, salinity, heavy metal toxicity, and diseases. CQDs perform various functions including sensing, bio-imaging, enhancing the antioxidant capacity of plants, promoting growth in plants through improved photosynthetic activity, priming effects on seed germination, delivery of bioactive molecules, and nutrient availability. CQDs' unique properties make them promising candidates for a wide range of applications beyond plant sciences including; environmental monitoring, wastewater treatment, food safety, agriculture and biomedical applications. Research has also suggested that CQDs can have negative impacts on plants i.e.; CQDs can reduce the light absorption of plants for photosynthesis by absorbing light itself, decreasing plant growth and yield. CQDs accumulation in plant tissues hinders the cellular processes and causes toxicity. CQDs affect soil micro-biota, necessary for plant growth and nutrient uptake, resulting in decreased plant growth and soil fertility. The purpose of this review paper is to draw attention to the latest findings on the potential use of doped CQDs as a beneficial method for managing plant stress. This could result in the creation of innovative approaches for promoting sustainable agriculture.

**OUTLINES**

1. **Introduction**

**2. CQDs Synthesis**

A. Chemical synthesis

B. Green synthesis

**3. Priming effects on seed germination**

## 4. Uptake, translocation and accumulation of CQDs in plants

## 5. Applications and impacts of pristine and engineered carbon quantum dots on plants under stresses.

* Abiotic stresses
* Biotic stresses

**6. Negative impacts of using CQD’s on plants**

**7. Nutritional significance of CQDs coated fertilizer**

**8. Uses of CQD’s; other than plant sciences**

**9. Conclusion and future perspectives**

A. Summary of the key findings and implications of the review

B. Limitations and challenges of using doped carbon quantum dots on plants under stress

C. Future research directions and potential applications of doped carbon quantum dots in plant science

**10. References**