**BIOTIC STRESSES**

Doped CQDs alleviates detrimental effects of biotic stresses through improving nutrients uptake, hormone levels and enhancing the antioxidant defense system against pathogen attack. Phytopathogen infection is a typical biotic stress that annually causes a significant decrease in crop productivity (Li et al. 2020). For instance, CDs enhance the rice plant disease resistance ability through inducing the over expression of related genes such as thionin (Os06g32600) (Li et al. 2018). Additionally, the CQDs were also degraded into CO2 and plant hormone analogues, which then promoted the rice plant growth, while the CO2 was converted into carbohydrates through the Calvin cycle of photosynthesis (Lahiani et al. 2016). Luo et al. (2021) reported that N-CDs (nitrogen doped carbon dots) suppressed bacterial wilt in tomatoes, statistically reduced disease severity by 71.19%. Studied showed, N-CDs were 1.56 times more effective at preventing disease than pure CDs (P-CDs). This indicates that’s N-CDs stimulated the anti-oxidative enzyme activity in plants, and then reduced the pathogen induced oxidative stress. Song et al. (2018) reported that the CDs extracted from cigarette smoke have antimicrobial activities, suggesting that the CDs can function as an effective broad-spectrum antibiotic, even against drug-resistant bacteria.

CQDs were tested for inhibitory activity against plants (B. cinerea, A. alternata, and F. oxysporum) using optical density as an estimate for spore growth. CQDs significantly reduced mycelial growth of P. infestans and sporangia development. CQDs enhanced the dsRNA-induced gene silencing in Phytophthora infestans and to evaluate the CQDs cytotoxicity (Kostov et al. 2022).

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