Pathogen Inactivation by Electrochemical Disinfection for Recirculating Hydroponic Irrigation Systems

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Introduction

Recirculating irrigation water allows greenhouse growers to reduce water and fertilizer use; however, there are several barriers limiting the adoption of this practice:

- Pathogen proliferation
- Accumulation of phytotoxic chemical contaminants
- Nutrient imbalances

Objective

Evaluate the pathogen control of Rhizoctonia solani using electrochemical inactivation techniques (Figure 1) with the novel Boron-Doped Diamond (BDD) and another electrochemical disinfection technology (Dimensionally Stable Anodes (DSA)) for the recirculation of greenhouse irrigation water.

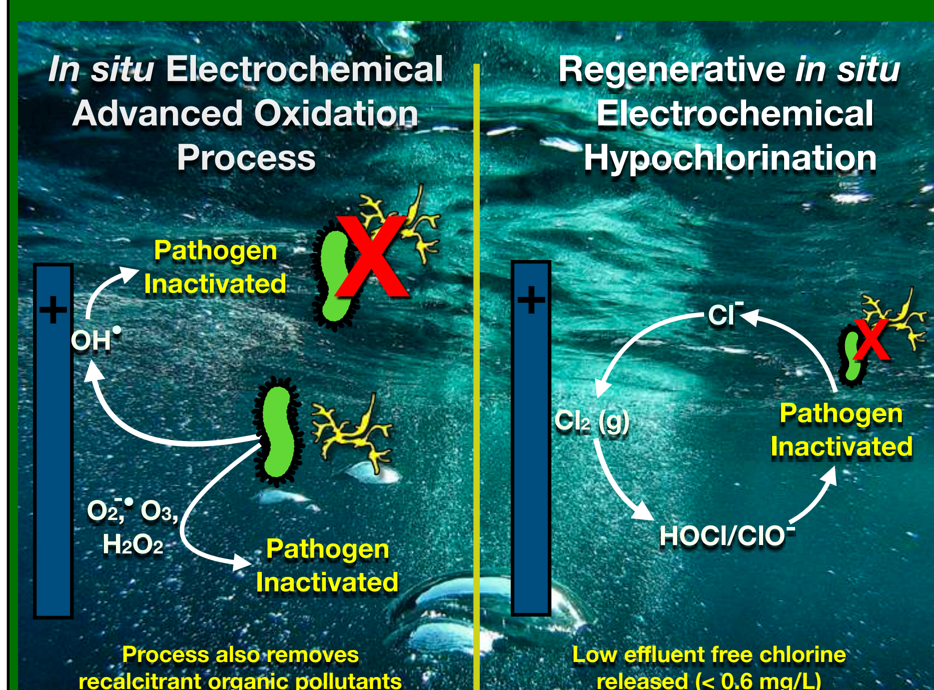

Figure 1: Propose mechanisms for pathogen inactivation with both BDD (EAOP) and DSA electrodes (regenerative hypochlorination). The BDD electrodes can combine both processes.

Methods

In figure 2, a fertigation solution (0.5 g/L 20-8-20 fertilizer and 15 mg/L of chloride) with pathogens added to the solution is pumped through the Electrochemical Flow Cell (EFC). The experiments were performed in triplicate and analyzing for the Colony Forming Units leaving the EFC, as well as the concentration of free chlorine and fertilizer ions.

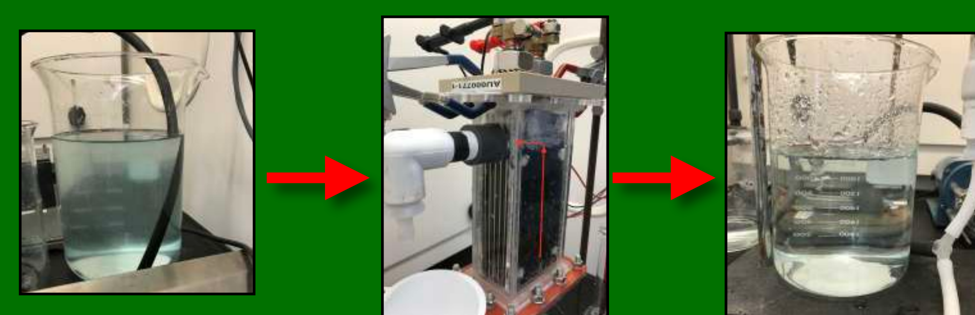

Figure 2: The initial pathogenated fertigation solution begins on the left and passes through the EFC and collected into a beaker following the red arrows.

Results

The EFC has shown the complete inactivation of *R. Solani* with BDD electrodes (9.09 mA/cm² and a 1-minute contact time) and DSA electrodes (4.55 mA/cm² and a 0.5-minute contact time). Also, the concentration of free chlorine for both systems is 20 times lower than the phytotoxic threshold for plants (2.5 mg/L) (Cayannan et al., 2009) (Figure 3).

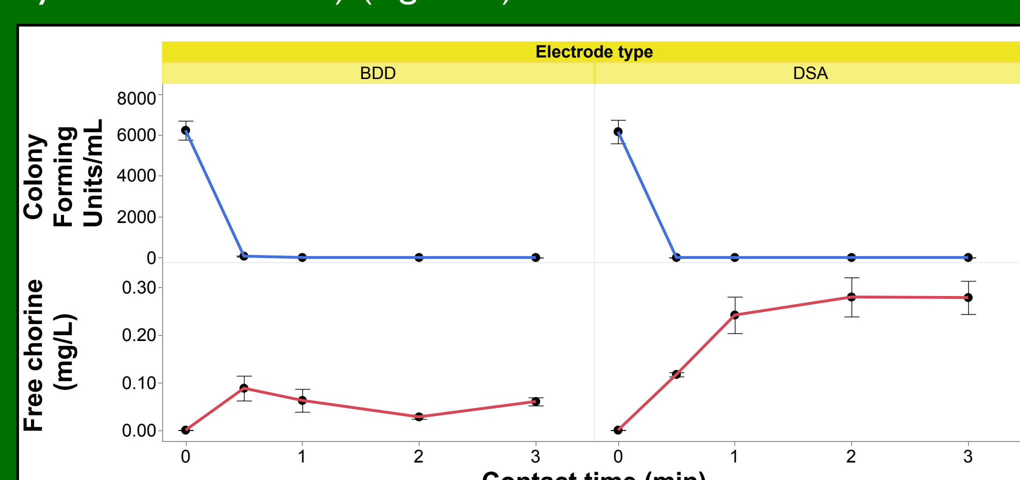

Figure 3: Inactivation of *R. Solani* and effluent free chlorine concentration from the BDD and DSA electrodes

Significant decreases was only observed for the ion chloride with both electrode types, while significant decreases were observed by ammonium for DSA electrodes (Figure 4). Significant increases in nitrate and ammonium was observed following treatment with BDD electrodes.

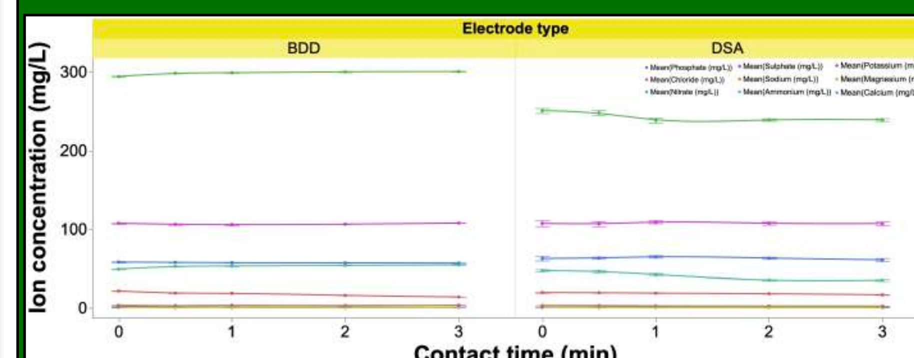

Figure 4: HPLC analysis of ions contained in the fertilizer that are essential for plant growth following treatment from BDD and DSA's.

Further analysis (not shown), confirms that significant increases in nitrate and ammonium are caused by the degradation of proteins and amino acids. Further, studies will be conducted on organic fertilizers to degrade proteins and increase available nutrients for plants

Conclusion

The study finds that both systems are able to reach the completely disinfect the solution, without surpassing phytotoxic levels and affecting the nutrient solution.

Acknowledgement

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Reference: Cayanan *et al.,* (2009) Efficacy of chlorine in controlling five common plant pathogens. *HortScience*, 44(1), 157 - 163.