

Interaction of Fe-MOF with hydroponic solution to understand the behaviour of nutrients for hydroponic cultivation

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Highlights

Controlled delivery of nutrients for soilless cultivation using MOF, promoting improvement to sustainable agriculture and production of healthy and nutritious foods.

Abstract

Sustainable technologies have been searched and developed, aiming at resolutions of environmental problems and sustainable development. Among the demands to achieve this are through the eradication of hunger, the achievement food security, the improvement nutrition and the promotion of sustainable agriculture (1). Science has helped to discover and develop technologies and mechanisms to solve several environmental problems. Despite its limitations, such as the stability of the hydroponic solution (HS) and bioavailability of nutrients, hydroponic emerges as an alternative to soil cultivation, mainly due to its efficiency, versatility and resource savings during cultivation. With the advancement of scientific research, new materials with diverse applications have been developed aiming to resolve current demands. Metal-organic frameworks (MOF), for example, is a versatile material that has been studied and applied for different purposes, such as catalysis and gas storage (2). Its use for the delivery of nutrients in plant cultivation is more recent (3). Therefore, the goal of this work is to investigate the interaction of Fe-MOF in presence and absence of HS to understand the behaviour of nutrients for hydroponic cultivation. A full factorial design for two factors (2² design) with one center point and two genuine replicates was proposed to investigate the interaction between HS and Fe-MOF and kinetic study was used to monitor the variations of elements in solution during the time. The two independent variables of the 2² designs were: Fe-MOF, whose mass was varied from 0 to 200 mg (0, 100 and 200 mg); and HS, whose concentration ranged from 0% to 100% (0, 50 and 100%). In falcon tubes, the respective mass of Fe-MOF was added, and the volume was completed with water and/or HS up to 15 mL and kept stirring for 2 hours. Then the experimental system was centrifuged, and the supernatant was separated for analysis. For the kinetic study, two experimental systems were set up: one contained 200 mg of Fe-MOF and 15 mL of HS, while the other contained 200 mg of Fe-MOF and 15 mL of water. Both systems were made in triplicate, such that for each time interval (0, 0.5, 1, 2, 4, 8, 12, 16 and 24h) there were six tubes, three from each system. As in the factorial design, the systems were kept under agitation for the determined time and were then centrifuged and the supernatants were separated for analysis. The concentration of Fe and other elements (Mg, Mn, P, Cu, Zn, Ca, K and B) were determined by ICP-OES. Results showed significant changes in Fe availability, from Fe-MOF, in presence and absence HS. Based on experimental design, it was possible to observe a peculiar behavior for Fe, such that there was more Fe available when there was only Fe-MOF and water than Fe-MOF and HS. The kinetic study confirmed these results, since the Fe concentration tends to increase over time in the Fe-MOF and water system, while in the Fe-MOF and HS system the Fe concentration remained almost constant. Regarding the other elements analyzed, there were no significant changes in their concentrations in the supernatant solution, their concentrations remained practically constant. This more controlled release of nutrients, as seen by Fe, can be advantageous for hydroponic cultivation, ensuring better use of HS nutrients and greater stability. Hence, these results lead to perceive synergy between MOF and HS that can influence positively plant cultivation by hydroponic.

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