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Slow-release of fertilizer in soil using pectin/calcium-bentonite hydrogel

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Plant survival and growth are greatly affected by moisture and nutrient loss around root zones. Water and nutrient retaining agents such as hydrogels have been gaining popularity to solve this problem, but most commercial hydrogels are composed of non-biodegradable and synthetic components. In this study, we successfully prepared hydrogels made of biodegradable pectin and naturally-occurring calcium bentonite. The synthesized hydrogels contained varied loadings of fertilizer (equivalent to 0, 0.2, 0.6, and 0.85 g NPK L⁻¹ soil). We characterized the hydrogels in terms of morphology (scanning electron microscopy/SEM), nutrient P and K concentration (X-ray fluorescence/XRF analysis), and degree of swelling in water (gravimetric method). We also determined the nutrient retention capacity and release of the hydrogels using a soil column leaching setup coupled with periodic monitoring of conductivity and total dissolved solids of column leachate.

SEM indicates the porous structure of the hydrogels, while XRF confirms the successful loading of fertilizer in the hydrogels. The hydrogel at 0.2 g NPK L⁻¹ soil has the highest degree of swelling in the water at 692.5%. The nutrient retentions of soil columns containing fertilizer-loaded hydrogels (0.2, 0.6, and 0.85 g NPK L⁻¹ soil) are greater by 35.5, 11.5, and 20.1%, respectively, compared to the control (soil column without hydrogel). Our measurements of fertilizer release rate also indicate that the presence of hydrogel in the soil column slows down the release of fertilizer as detected in the column leachates. We conclude that the pectin/calcium-bentonite hydrogels are effective in retaining water and reducing the release of fertilizer from the soil. With the biodegradability of pectin and natural occurrence of calcium bentonite, the hydrogel has the potential for sustainable management of slow-release fertilizer systems.