Humic Acid-Enriched Biopolymer Hydrogels: Water Retention, Biodegradation, and Sorghum Growth

Water scarcity is one of the most limiting factors for agricultural productivity in arid and semi-arid regions. Hydrogels, as three-dimensional polymeric networks, have emerged as promising soil conditioners due to their ability to retain water and act as carriers for nutrients or plant growth-promoting agents. However, most commercial hydrogels are based on synthetic polymers such as polyacrylates, which exhibit limited biodegradability and raise environmental concerns. This has stimulated interest in the development of biobased and biodegradable hydrogels for sustainable agriculture.

In this study, we designed and developed superabsorbent hydrogels based on gellan gum (GG), karaya gum (KG), and humic acid (HA) as eco-friendly alternatives for agricultural applications. The hydrogels were characterized by FTIR, TGA, SEM, mechanical assays, and swelling kinetics. Water retention tests indicated that both GG/HA and GG/KG/HA hydrogels preserved higher soil moisture compared to a commercial polyacrylate hydrogel. Soil biodegradation assays demonstrated that the biopolymer hydrogels lost more than one-third of their weight after 30 days, confirming their degradability under natural conditions.

Biological assays were carried out using sorghum (*Sorghum sp.*) seedlings germinated in a growth chamber at 27±1 °C with a 12 h photoperiod. Both GG/HA and GG/KG/HA hydrogels exhibited no phytotoxicity, while the GG/KG/HA formulation promoted higher growth and chlorophyll accumulation compared to GG/HA.

Overall, GG/KG/HA hydrogels proved to be biodegradable, biocompatible, and effective soil conditioners, positioning them as promising candidates to improve soil quality and crop productivity in sustainable agriculture.

Keywords: biodegradable hydrogel, soil biodegradation, sorghum.