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Carboxy-methyl tamarind kernel gum based bio-hydrogel for sustainable agronomy

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ABSTRACT

The innovative superabsorbent bio-tech hydrogels were concocted by free radical polymerization of sodium-methacrylate & carboxymethyl tamarind kernel gum, for application in agronomical procedures as a soil conditioner & water harvester for sustainable agronomy. The structural morphologies of the hydrogel were characterized by techniques viz. Fourier transform infrared spectroscopy, scanning electron microscopy, and thermogravimetric analysis. The hydrogel was evidenced as a biodegradable hydrogel via the soil burial biodegradability test. The swelling behavior of hydrogel was analyzed as a function of temperature, pH, and salt solutions. The formulated hydrogel engrossed 248 ml/g water and 0.5% CMTKG-PSMA hydrogel amended soil revealed augmentation in the maximum water holding capacity (46.5%), porosity (14%), shoot length (43%), available water content (37%). A decrease in bulk density (8%) was also observed. The water intake was Fickian diffusion following Korsmeyer-Peppas Equation. These upshots were validated upon chickpea plants. These hydrogels proffer a promising substitute as a soil conditioner in agronomy.

1. Introduction

Water's pivotal role and exorbitant usage in agronomical practices viz. irrigation, nutrient and pesticide application, crop cooling, and frost control, has opened a new outlook in research to develop innovative technologies for water's sustenance by effectual use with less wastage for global economic balance and food security. Henceforth, various practices are being explored that make the plants accessible to high available water content and lower the frequency of irrigation [1].

Biopolymer-based organic hydrogels are greener and more eco-friendly practices for keeping the soil moistened and nourished. Their greener attributes viz. non-toxicity, biodegradability, and higher water intake and retention capability shield the environment and natural resources and enhance plant growth and crop productivity [2]. The hydrogel amendment of the soil for agronomy is technically, socially, economically, and environmentally sustainable. These organic hydrogels contribute beneficially towards the soil morphologies, density, texture, permeability, evaporation, and infiltration rates of water through it. They boost the water holding capacity, water use efficiency, soil infiltration rate, and permeability. And, at the same time, drive down soil compaction, surface water run-off, soil erosion, leaching, evaporation of water, and seepage into the ground. They make the water content of the soil readily available to the plants, owing to their property of adhesion to the roots.

Scientifically, hydrogels constitute a group of three-dimensional cross-linked polymeric materials, which owing to the presence of hydrophilic functionalities in them, have the potential to entrap or release variable amounts of water/biological fluids reversibly (swell or shrink), in response to the external stimuli (physical/chemical/biochemical - temperature, solvent, pH, electric field, etc.), without altering the core matrix framework of the polymers. Witchterle and Lim prepared hydrogel for the first time in the 1960 s [3]. Various methods of synthesis of hydrogels include graft polymerization [4], free radical polymerization [5], crosslinking [6], frontal polymerization [7], and ionic radiation technique [8]. Cross-linking in hydrogels is usually achieved either through physical linkages viz. Vanderwaal forces or electrostatic interactions or hydrogen bonding [9]; or through chemical linkages via covalent bonds [10] formation during polymerization. Hydrogels formed owing to chemical linkages [11] are preferred in comparison to hydrogels involving physical linkages as the physical linkages disrupt easily due to weaker interactions. Chemically crosslinked Hydrogels [12,13] have been successfully applied in various areas.

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