Biopolymer-Based Microcarriers for Controlled Nutrient Release: A Sustainable Alternative to Commercial Fertilizers

Naveen Prabhu, Navnith (School: Round Rock High School)

Over 50% of applied fertilizer is lost due to leaching and runoff, causing resource wastage, soil degradation, and water pollution. While there are alternatives in the form of controlled - release fertilizers, they are usually based on non - biodegradable synthetic polymers, which often persist in the environment. My project aims to solve this problem by engineering biodegradable biopolymer - based microcarriers that can release nutrients in a controlled manner while supporting healthy plant growth. I researched several polymers before finally selecting Sodium Alginate and Pectin, as they were biodegradable, food - safe biopolymers that were able to be crosslinked safely. I then proceeded to go through multiple trials of varying concentrations before finally being able to form bead - like microcarriers that could encapsulate NPK fertilizer. I tested these microcarriers in a swelling test that would determine swelling ratio, water uptake, and nutrient retention properties. Then, I used an electrical conductivity test to analyze each microcarrier's nutrient leaching pattern. Finally, I showcased the difference between the Commercial Controlled Release Fertilizer and my own microcarriers through a series of plant growth trials conducted using Vigna radiata and Raphanus sativus in both topsoil and typical home garden soil. Alginate - based microcarriers consistently achieved the highest composite growth scores, demonstrating superior plant growth while maintaining low nutrient leaching. Using a Statistical Model, I proved that my microcarriers had no significant difference in performance from Commercial CRFs. In the future, I will incorporate micronutrients such as Zinc, Iron, and Magnesium, as this could improve plant nutrition, especially in places with barren soil.

Awards Won: