Bugged Out, A Novel Approach to Reforestation: Developing a Biodegradable Multi-Modal Pest Deterrent Composite (MPDC) via Biopolymer Encapsulation of Amorphous Silica and Capsaicin for Broad-Spectrum Seed Protection

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Large-scale reforestation efforts often struggle due to the large cost associated with seeding and low growth yield due to pest predation on seeds. To negate pests, blanket application of chemical pesticides is applied to seeding areas, however these pesticides are both environmentally harmful and costly. This study aims to produce a biodegradable gel that encapsulates natural pesticides which can be set around tree seeds for a targeted, environmentally-friendly, and cost effective method of reforestation. The biodegradable multi-modal pest-deterrent composite (MPDC) chemical matrix was synthesized using gelatin, low methoxyl pectin ionically crosslinked with divalent calcium cations (Ca2+), microcrystalline cellulose, and glycerol, with amorphous silica, emulsified capsaicin, and peppermint oil acting as mechanical, olfactory, and chemical deterrents respectfully. To finalize MPDC formulation, twelve iterative qualitative tests were conducted. SEM imaging, EDS analysis, and an ANOVA tensile comparison proved Trial #12 to be the most balanced formula for seed usage. A simulated soil degradation experiment showed the MPDC to significantly last through seed imbibition with a 95 percent retention threshold ($t = 12.78$, $p = 0.00011$). Behavioral trials using Pogonomyrmex barbatus (red harvester ants) showed statistically significant avoidance of MPDC-treated seeds using Monte Carlo spatial analysis with Benjamini–Hochberg correction. Cost analysis estimated that MPDC protection would cost approximately $96 per hectare at a planting density of 2,000 seeds, approximately 97.4 percent lower than reported traditional methods. Together, this MPDC formulation and method functions as a cost effective, functional, and environmentally-friendly method of reforestation.

Awards Won:
Fourth Award of $600