Comprehensive Biomimetic Aerial Seed Coating Inspired by the Fruit Structure of Burma Padauk for Enhanced Seedling Establishment and Growth in Mixed Deciduous Forest Restoration

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Mixed deciduous forests are biodiversity-rich ecosystems that support wildlife habitat and ecological balance. Their restoration has become an urgent environmental priority due to deforestation, wildfires, and forest degradation. Aerial seeding is a promising strategy for restoring inaccessible degraded forests; however, its effectiveness is limited by seed damage, low dispersal efficiency, poor seed clustering, and insufficient nutrient availability for seeding survival. To tackle these, The biomimetic aerial seed coatings inspired by the fruit structure of Burma Padauk (Pterocarpus macrocarpus) have been developed for mixed deciduous forest restoration. Based on the fruits structural characteristics, I designed symmetrical and asymmetrical wavy molds to optimize the various seed types. The coating was produced from carboxymethyl cellulose (CMC) derived from Actinoscirpus grossus, sugarcane leaf-derived silica, rice husk biochar, and sterilized layer chicken manure. The optimal formulation, CSRL20, contained 0.75 g CMC and 0.50 g each of biochar, silica, and manure. Afzelia xylocarpa and Dipterocarpus alatus seeds dispersed most effectively with the symmetrical design, while Xylia xylocarpa seeds performed better with the asymmetrical design. UAV-based dispersal tests at release heights of 20, 30, and 40 m showed that coated seeds dispersed significantly farther than uncoated seeds across all three species (up to 4.5X), while simulation results were consistent with field observations. The coated seeds achieved higher survival rates (73-87%) in degraded forest and nursery conditions and enhanced seedling height over 150 days. This work highlights a scalable, biodegradable, and agriculture-waste-based restoration method for the sustainable recovery of forest ecosystems.

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