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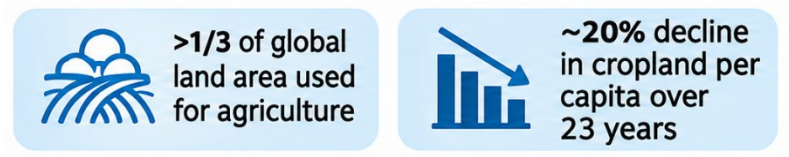
Evaluation of Cellulose-Filled Filaments for the Fabrication of Sustainable Structures for Vertical Farming

"Avaliação de filamentos com carga de celulose para fabricação de estruturas sustentáveis aplicados à agricultura vertical"

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Introduction

Modern agriculture faces increasing pressure due to limited land availability, urbanization, and the growing demand for safe food. Additive Manufacturing enables tailored cultivation structures, while cellulose-containing filaments and hydrogels offer promising opportunities for sustainable plant-growth scaffolds.

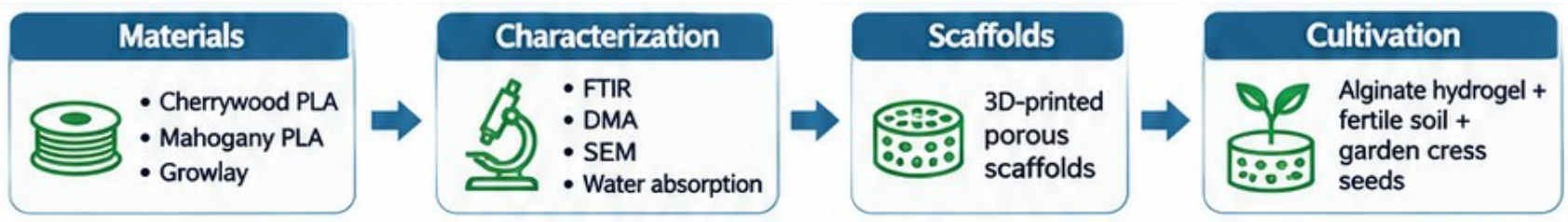


Source: FAO (2026)

Objectives

- Characterize commercial cellulose-containing filaments;
- Evaluate water absorption, retention, and structural stability;
- Develop and assess 3D-printed scaffolds integrated with hydrogel for plant cultivation;

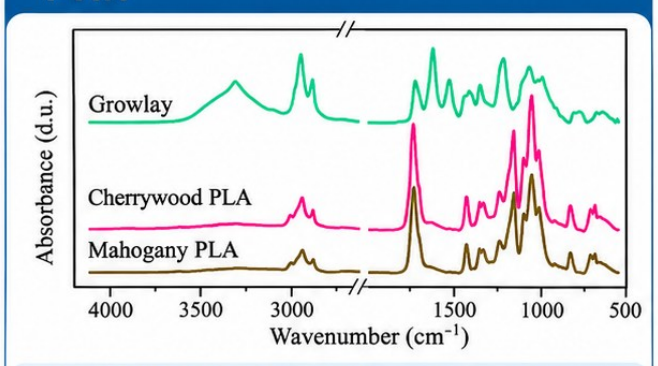
Materials and Methods



Workflow from material characterization to scaffold cultivation assessment.

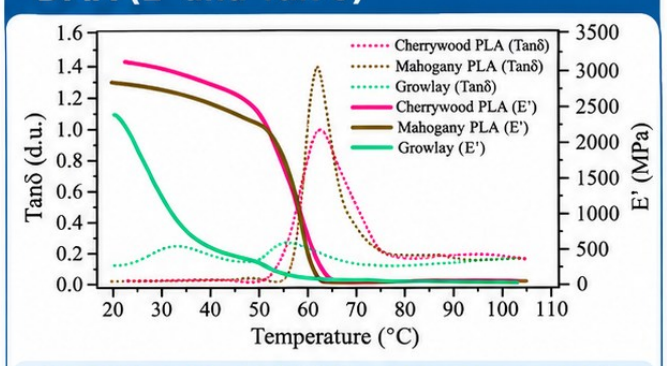
Results and Discussion

FTIR



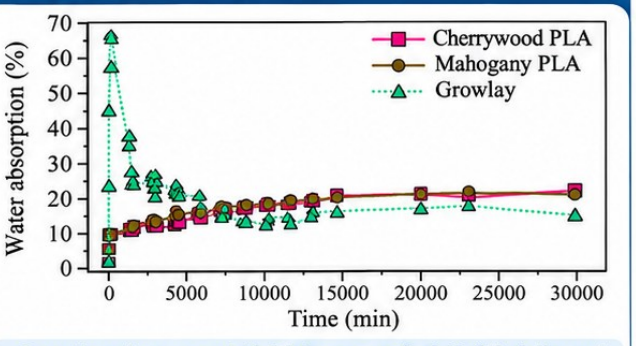
Wood-filled PLAs show similar spectra, while Growlay exhibits a pronounced O–H band (~3300 cm⁻¹).

DMA (E' and Tan δ)



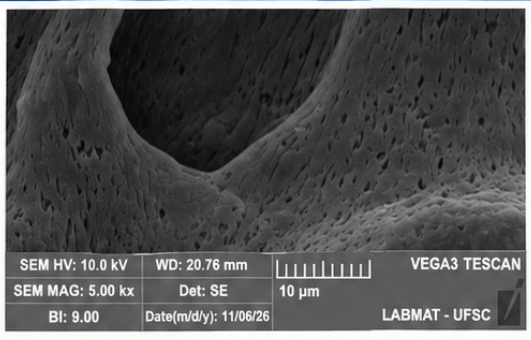
Wood-filled PLAs retain higher stiffness up to ~60 °C; Growlay softens earlier and exhibits broader relaxations.

Water Absorption



Growlay shows rapid initial mass gain (~67%), followed by a decrease potentially associated with soluble-phase extraction. Wood-filled PLAs stabilize at ~20–22%.

SEM – Growlay (5000×)



Growlay contains a water-extractable phase; its removal can increase porosity and facilitate water transport.



Garden cress cultivation demonstrates the feasibility of hydrogel-integrated porous scaffolds for early plant development.

Conclusions

- Material composition strongly affected stiffness, damping, and water uptake behavior.
- Growlay showed higher water affinity, while wood-filled PLAs provided greater thermomechanical stability.
- The proposed scaffolds supported early plant development and are promising for vertical-farming applications.

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Reference

- FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO). Land statistics 2001–2024: global, regional and country trends. Rome: FAO, 2026. Disponível em: https://www.fao.org/statistics/highlights-archive/highlights-detail/land-statistics-2001-2024.-global--regional-and-country-trends/en. Acesso em: 3 set. 2026.