Tree bark: a promising substrate for mycelium-bound composite biomaterials

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Abstract

Bark is currently considered a by-product of the wood industry and is mainly incinerated for energy, left in forests, or used as mulch in gardens, parks, and forests to prevent soil drying. Given that bark constitutes about 10–20 % of tree volume, it represents a substantial underutilized resource that should be examined within a resource-efficient bioeconomy. One promising approach to increase both its economic value and carbon storage potential is its use as a substrate in mycelium-bound composite materials. However, as bark naturally inhibits microbial infestation, its suitability for fungal growth remained unclear. Therefore, this study investigates the feasibility of producing mycelium-bound composites by evaluating different bark–fungus combinations. Three bark types (Douglas fir (*Pm*), Scots pine (*Ps*), and European birch (*Bp*)) and two fungal species (*Ganoderma adspersum* and *Ganoderma resinaceum*) were selected. Mycelium growth rates were assessed using a newly developed method based on fungal growth tubes. In addition, composites were produced from pure bark and from a 1:1 mixture of bark and European beech (*Fs*) wood sawdust for performance testing. Composites containing mixed bark and wood were generally well overgrown with dense surface mycelium, resulting in higher compression strength. In contrast, bark-only composites exhibited thinner mycelium layers and lower strength. Water absorption strongly depended on surface mycelium thickness, which showed pronounced hydrophobic properties. Although incubation times were longer than those for common substrates such as hemp shives, straw, or wood shavings, the results demonstrate that bark is a promising co-substrate for mycelium-bound composites with potential applications in packaging, construction, and insulation.

Substrates

Fig. 1: Overview of the substrates used in this study. Douglas fir (*Pm*) bark (I), Scots pine (*Ps*) bark (II), and European birch (*Bp*) bark (III). 50:50 ratio mixtures: Douglas fir bark with beech wood (*Fs*) (IV), pine bark with beech wood (V), and birch bark with beech wood (VI). Scale bars represent 10 mm.

Growth-speed on bark substrates

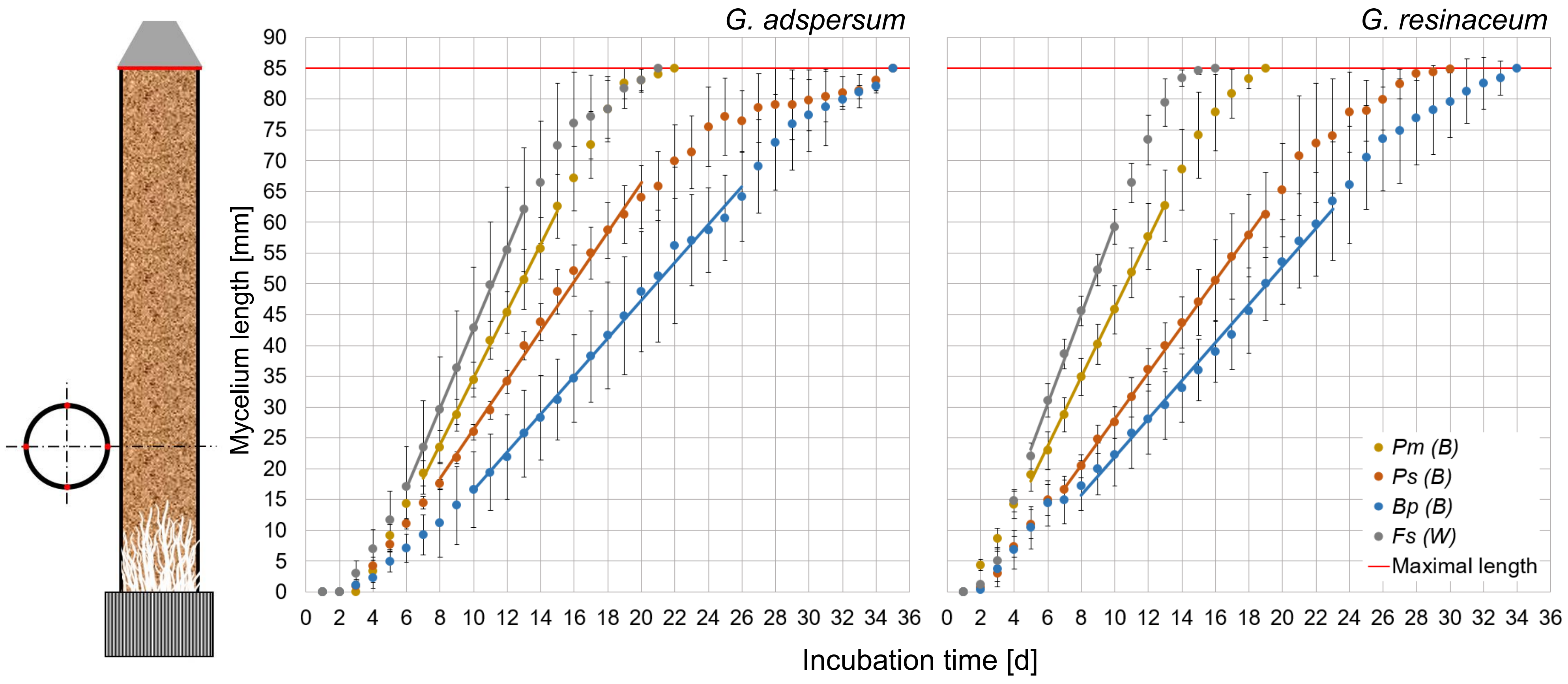


Fig. 2: "Growth-tube" method highlights substrate-dependent differences in colonization performance. 15-mL laboratory tubes were cut and sealed at the top, filled with substrate and water, and autoclaved. They were then inoculated with 10 grains of grain spawn at the screw area of the tube, closed, and incubated (n=8). Mycelium length was measured daily at four points to calculate the growth rate (mm/day) in the linear region of the growth curve between 15 and 65 mm ($R^2 = 0.99$). European beech (*Fs*) wood was used as a reference. Abbreviations: *B* – bark; *W* – wood.

Water absorption properties

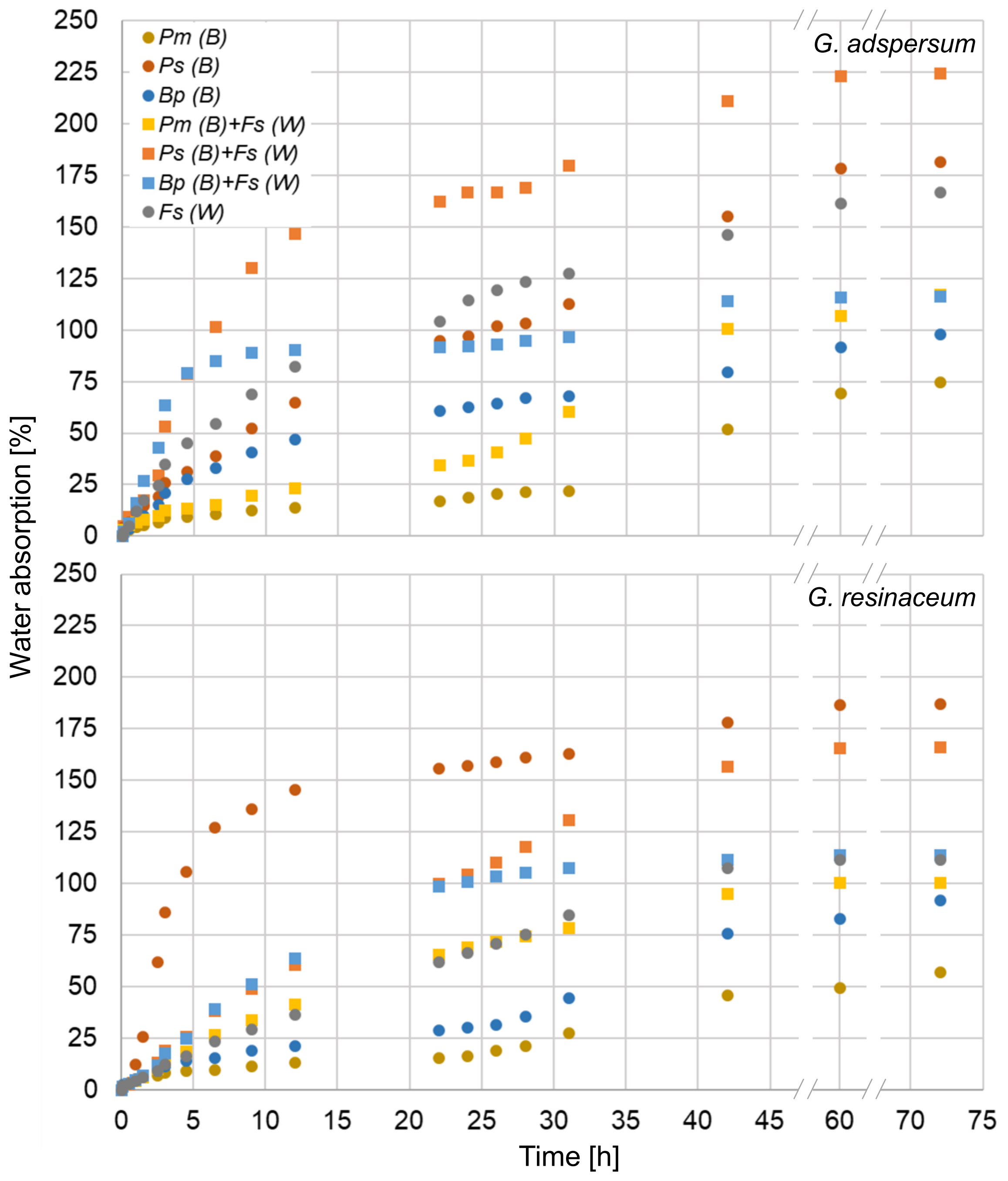
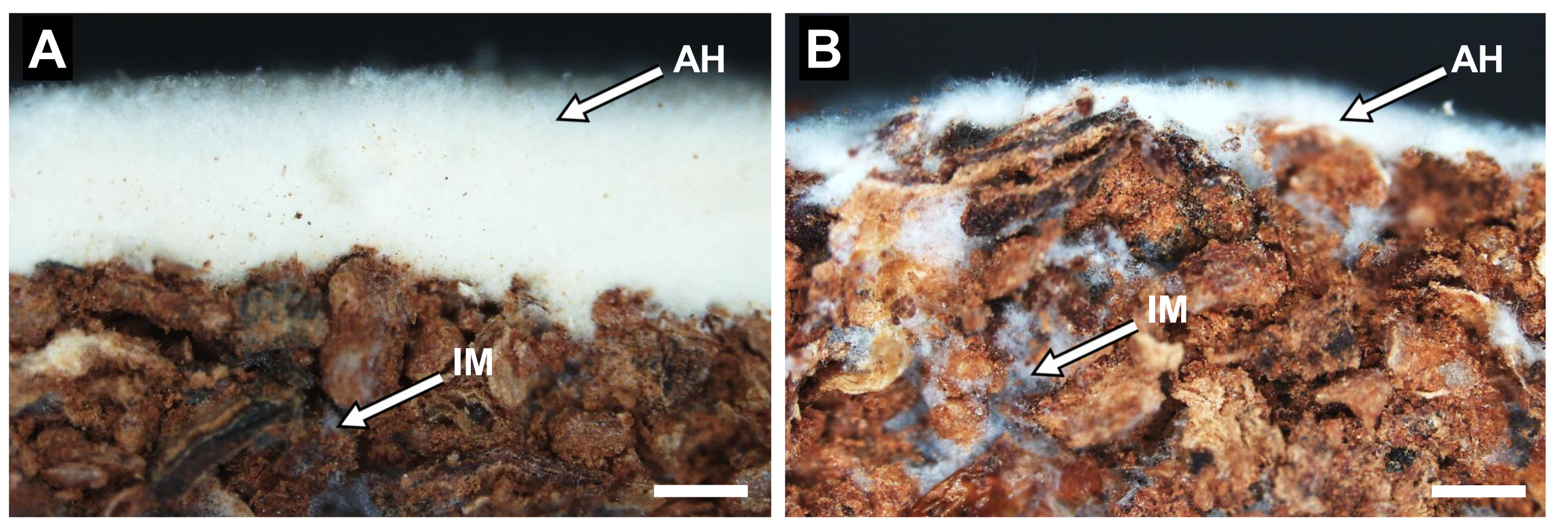


Fig. 4: The water absorption strongly depends on bark type. Composites (n=4; 10 wt.% grain spawn) were immersed in water for up to 72 hours and weighed at regular intervals to assess the water absorption capability. Pine bark (*Ps*) exhibited hydrophilic properties, whereas Douglas fir (*Pm*) and European birch (*Bp*) bark were more hydrophobic and showed lower water absorption.

Morphological traits



Cross-sectional images of mycelium-bound composites. AH – aerial hyphae; IM – ingrown mycelium. Scale bars represent 500 µm.

Fig. 3: The *Ganoderma* species exhibit different outer mycelium layer thicknesses on different bark types. The visible differences that occurred in several fungus-substrate combinations were especially prominent in case of birch bark with *G.a.* (A) and with *G.r.* (B).

Ultimate compressive strength

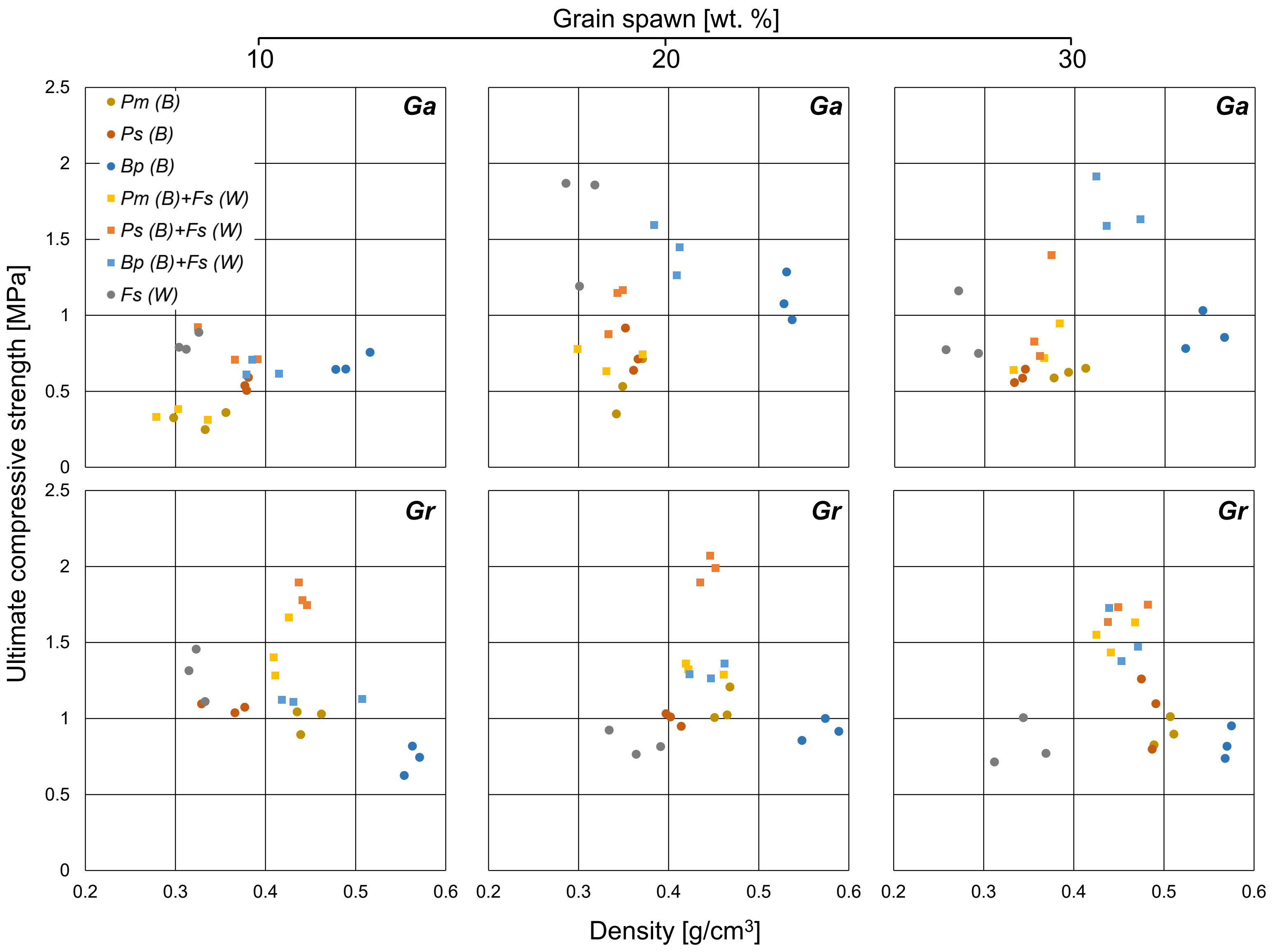


Fig. 5: Ultimate compressive strength depends on substrate, fungal species, and grain spawn (GS) content. For cylindrical specimens (n = 3), strength increased with a thicker outer mycelium layer, observed for mixtures of birch or pine bark with beech wood. At similar densities, the best performance was obtained for pine mixture with *G. r.* (10 % GS) and birch mixture with *G. a.* (30 % GS).

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Conclusions

- The "growth-tube" method effectively detected substrate-dependent differences in colonization rate.
- Overall, *G. resinaceum* formed denser, stiffer materials with structural potential, while the composites made with *G. adspersum* were more flexible, fit for impact-absorbing applications.
- Water absorption mostly varied with substrate, with modifying potential of the outer mycelium layer. While pine bark composites generally showed the highest uptake, it was lowest for Douglas fir.

Reference: Felle, T. K., Estenfelder, J., Wenig, C., Berendt, F., Eder, M., Cheng, T., & Benz, J. P. (2026). Tree bark as a substrate for mycelium-bound composites with two *Ganoderma* species. Discover Materials, 6, 30. https://www.doi.org/10.1007/s43939-025-00507-0