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**Effect of environmental factors on anatomical, chemical,
physical and mechanical properties of Hungarian black
locust (*Robinia pseudoacacia* L.) wood as function of
geographical locations**

By

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Introduction

It is a well-known fact that the atmospheric concentration of greenhouse gases (GHG) continues to increase globally (Lamb et al. 2022). Consequently, this rise has resulted in a significant increase in global temperatures. Localized data demonstrates these trends in Napkor, Hungary, a region known for significant black locust cultivation. The average temperature in 2021 was 10.7 °C. This shows a 0.3 °C increase compared to the mean temperature observed over the 1985–2020 period.

Changes in growth conditions can physiologically impact wood quality, depending on the tree species. This influence is often manifested through alterations to the wood anatomical structure, such as the number of vessels, ray, parenchyma, fiber, and widths, and vessel characteristics (Usta et al. 2014, Zhang et al. 2020, Nazari et al. 2020).

Robinia pseudoacacia L. is a species of considerable value and history in Hungary, having been cultivated for 300 years (Rédei 1999; Rédei and Meilby 2000; Rédei and Meilby 2009). It is extensively planted in both pure and mixed stands across diverse ecological zones (Rédei et al. 2008), currently comprising 24.42% (458,296 ha) of the total forested area (Csaba, 2023). Recognizing its economic importance, Hungary has implemented several programs, such as the INCO-

COPRNICUS project, specifically aimed at resolving cultivation limitations and enhancing wood quality. These strategic efforts have successfully driven the development of superior clonal materials (Rédei et al. 2020).

Considering the wide geographical distribution of *Robinia pseudoacacia* L., trees within Hungary, we assume that:

- The internal structural of *Robinia* wood can be influenced by site-specific growth conditions.
- The site-related factors play a crucial role in chemical composition of *Robinia* wood.
- The Variability in physical and mechanical properties of *Robinia* wood can be attributed to differences in site and growth conditions.

Research Objectives

The main objective of this study is to investigate the wood characteristics of *R. pseudoacacia* L. from five Hungarian counties and among three growth conditions.

Specific objectives are:

- 1- To investigate the anatomical features
 - ✓ Wood fiber length, width, wall thickness and lumen diameter
 - ✓ Vessel length and width

- ✓ Width of the annual ring.
- 2- To analyse the organic and inorganic composition
 - ✓ Ash content (%)
 - ✓ Extractives content (%)
 - ✓ Total polyphenol content (mg GAE/g dw)
 - ✓ Antioxidant capacity (mg AA/g dw).
- 3- To determine physical properties
 - ✓ Wood density
 - ✓ Wood shrinkage and swelling (radial, tangential and volumetric)
 - ✓ Wood color parameter
- 4- To investigate the mechanical properties
 - ✓ Modulus of rupture
 - ✓ Modulus of elasticity
 - ✓ Compressive strength parallel to the grain

Materials and Methods

From the bottom and top of trees, a total of 22 sample logs were obtained from nine locations across Hungary (Northern, Central, and Western). These locations represent five counties. The examined sites were classified into three growth conditions based on soil characteristics: GGC–good growth conditions, PGC–poor growth conditions and MPGC–mixed species under poor growth conditions as defined by Várallyay (2015) and Tóth et al. (2007).

Sampling

Three discs, each measuring 4 cm in thickness, were taken from every log at breast height (130–140 cm).

Anatomical properties

Fiber properties

The fiber and vessel characteristics were assessed using a light microscope integrated with a digital camera (Nikon Eclipse, Nikon, Japan) and ProScan III software (V31XYZ/D, Prior Scientific Instruments Ltd., Wilbraham Road, Fulbourn, Cambridgeshire, CB21 5ET, UK).

Ring width

The smooth strips were scanned using a scanner (CanonScan LiDE 110, Canon, Japan) (Abramoff et al. 2004). Then, the annual ring widths were measured with ImageJ software.

Chemical Compositions

The ash content, chemical extractives, total polyphenol content, and antioxidant capacity were investigated using wood particles (Fodor and Hofmann 2024).

Physical properties

Color parameters (lightness, redness and yellowness)

The CIELAB parameters were determined using the D65 illuminant. Thirty replicates were measured from wood samples for each location within the county, with a test-window of 5 mm in diameter (Tolvaj and Varga, 2012; Baar et al. 2019).

Density, shrinkage and swelling

From both bottom and top logs, a total of 347 samples, each sized $20 \times 20 \times 30$ mm, were used to evaluate moisture content, basic density, density at 12% moisture content, and linear shrinkage and swelling across all counties (ISO 13061, 2017 and ISO 13061, 2014).

Mechanical properties

Samples sizes around $20 \times 20 \times 300$ mm were prepared to evaluate the modulus of elasticity and rupture. The test specimens were done by INSTRON testing machine according to ISO 13061-4: 2014 and ISO 13061-3: 2014. The compression strength parallel to the grain was obtained according to ISO 13061-17:2017. Samples size of specimens was $20 \times 20 \times 30$ mm.

Results and main conclusion of the research

Thesis 1: Anatomical feature of wood *Robinia pseudoacacia* L., across Hungary and among the growth conditions

I establish that the length, width, wall thickness of fiber and vessels length and width of wood *Robinia pseudoacacia* L. were greatest in Szabolcs-Szatmár-Bereg and Vas. Among the growth conditions, I found that in poor growth conditions (mixed species) and good growth conditions produced superior wood fiber properties and ring widths.

Thesis 2: Relationships of Fibers length and Ring Width with Precipitation and Temperature on Wood of *Robinia pseudoacacia* L.

I proved that the fiber length, width, and cell wall of *Robinia pseudoacacia* L., from Bács Kiskun increased from pith to bark. While the lumen diameter remained without change. I found that the fiber length and ring width were not significantly correlated with precipitation and temperature.

Thesis 3: Chemical compositions and color parameters of *Robinia pseudoacacia* L., wood across Hungary and among the growth conditions

I found that *Robinia pseudoacacia* L., from Vas and Győr-Moson-Sopron exhibited the highest total contents of extractives, polyphenol, antioxidant capacity and intense lightness. Under growth conditions, MPGC yield higher chemical composition. I also found that the extractives from the cyclohexane-ethanol solvent significantly correlated with all color parameters and conversely with total extractives content.

Thesis 4: Densities, shrinkage and swelling of wood *Robinia pseudoacacia* L., across Hungary and among the growth conditions

I found that the air-dry and basic density of *Robinia pseudoacacia* L., were highest in Bács Kiskun County and lowest shrinkage and swelling. I found that The PGC revealed greatest densities, and tangential and longitudinal shrinkage. While the MPGC recorded the greatest values for volumetric shrinkage, radial, tangential and longitudinal and volumetric swelling. I found that there were no significant differences in linear and volumetric swelling between the growth conditions.

Thesis 5: Mechanical properties of wood *Robinia pseudoacacia* L., across Hungary and among the growth conditions

I found that the Bács-Kiskun has the highest mean values for MOE, while the highest MOR and CS were greatest in Győr

Moson Sopron. I found that the MPGC demonstrated the highest MOE, whereas the MOR and CS were greatest in PGC.

I proved that the sites specific factors and growth conditions significantly affected the wood properties of *Robinia pseudoacacia* L., in Hungary. With highest studied properties in Vas County and MPGC.

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