

Comparing the effect of artificial drought and crown reduction on tree ring response in sessile oak and Norway spruce seedlings

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Introduction

Summary

We analyzed the anatomical response of three-year-old seedlings of *Quercus petraea* (Matt.) Liebl. (sessile oak; ring-porous) and *Picea abies* (L.) H. Karst. (Norway spruce; conifer) to crown reduction and application of hydrogel in substrate. Our results demonstrate contrasting stem biomass allocation patterns in the two species.

Context

- Following extensive deforestation caused by tree mortality, it is essential to have robust regeneration material that can withstand the initial establishment shock and effectively restore the area.
- In a short-term experiment we treated 3-year-old plants with hydrogel application in substrate and 50% crown reduction, and followed their development in dry and wet conditions over a two-year period (2021–2022).
- We hypothesized that both treatments would have a beneficial or ameliorative effect on radial increment under dry conditions.

Methodology

Experimental design

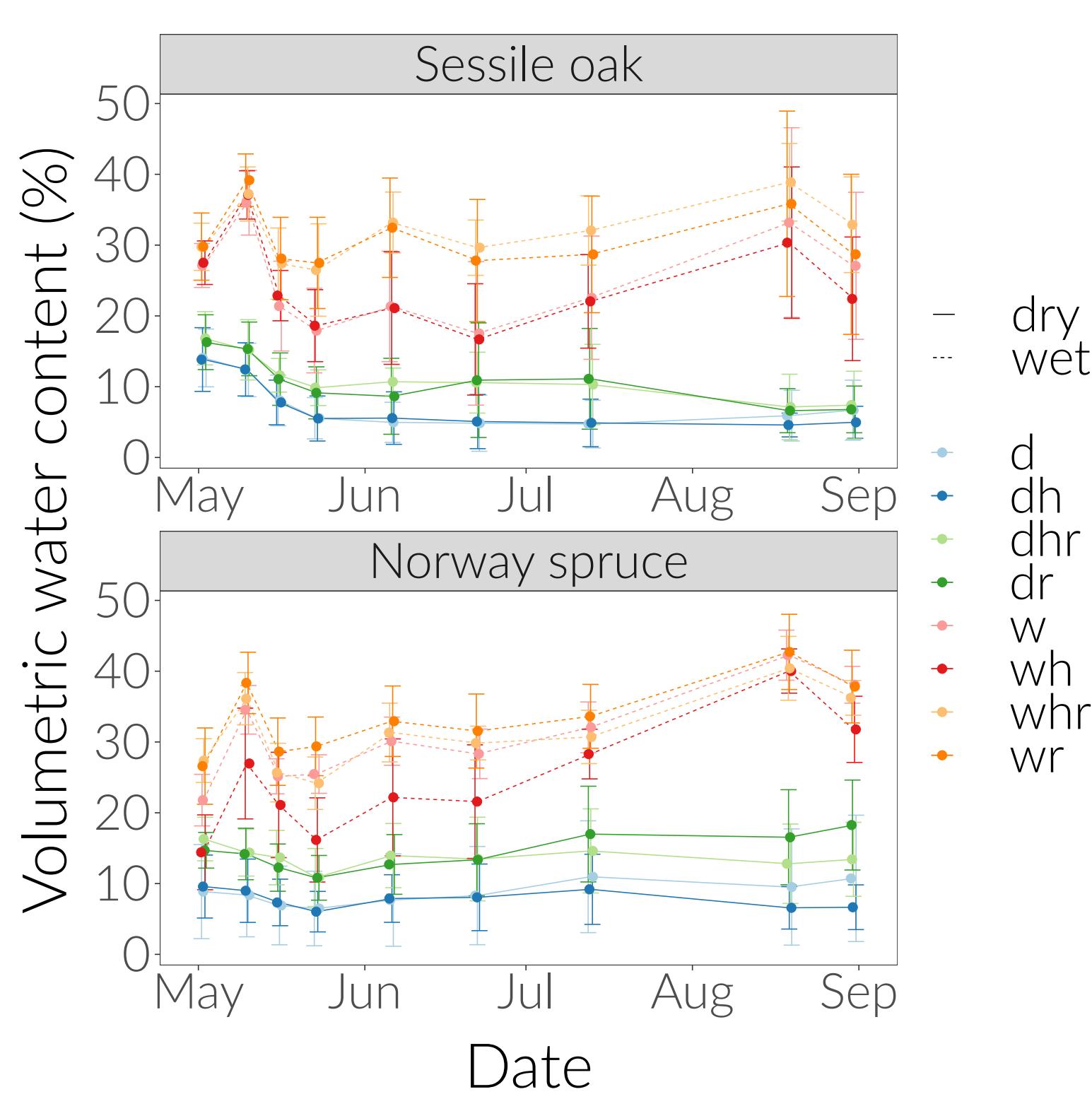


Figure 1. Crown reduction lowers the plant water use. Volumetric water content (%; 30 cm depth) in seedling substrate, second year of the experiment (2022)

Wood anatomy

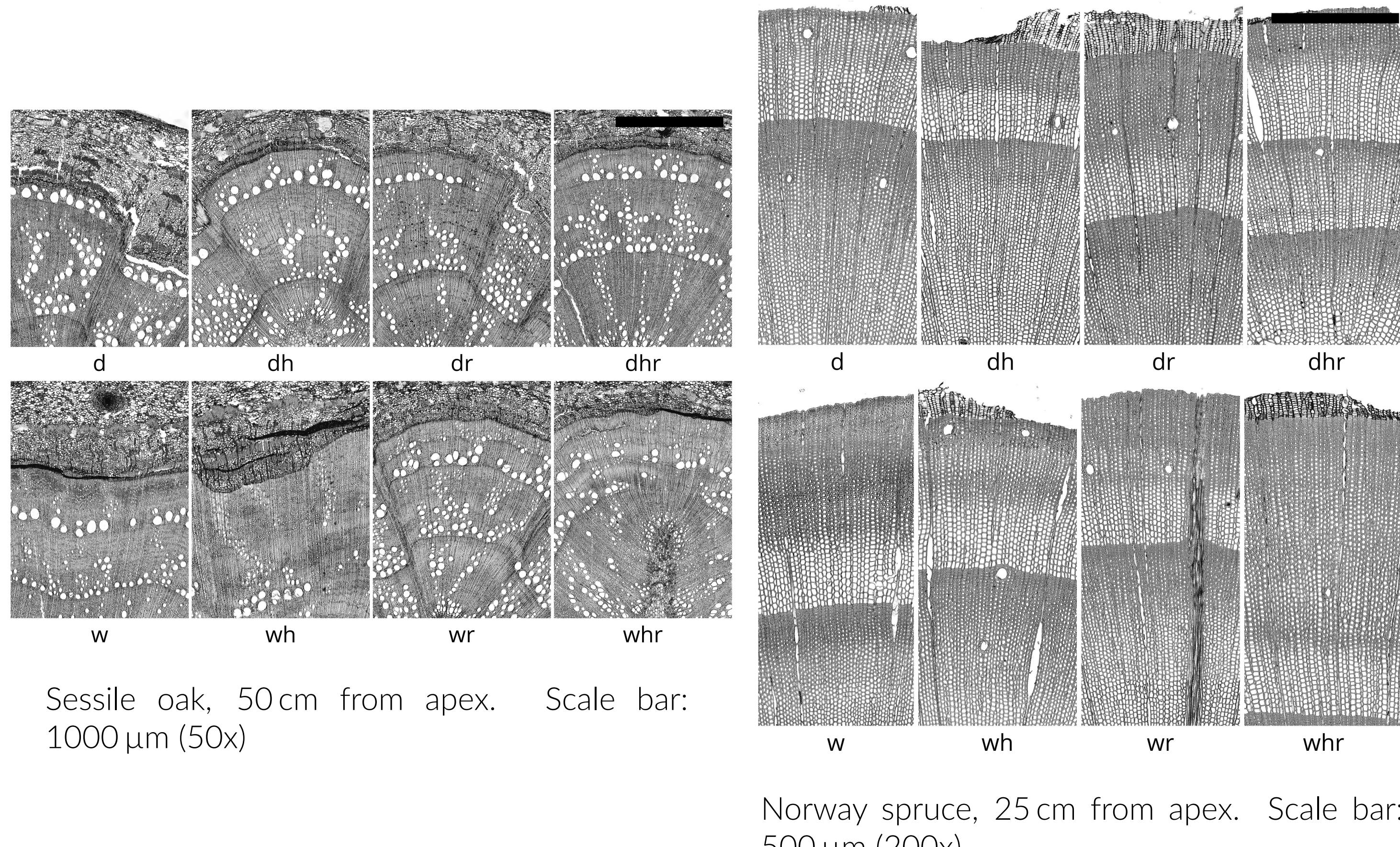


Figure 2. 10 µm-thin selected stem transverse sections of sessile oak (left) and Norway spruce (right)

Results

Sessile oak

Sessile oak appeared to be very responsive to drought treatments by reducing tree-ring width and increasing vessel diameter and vessel density.

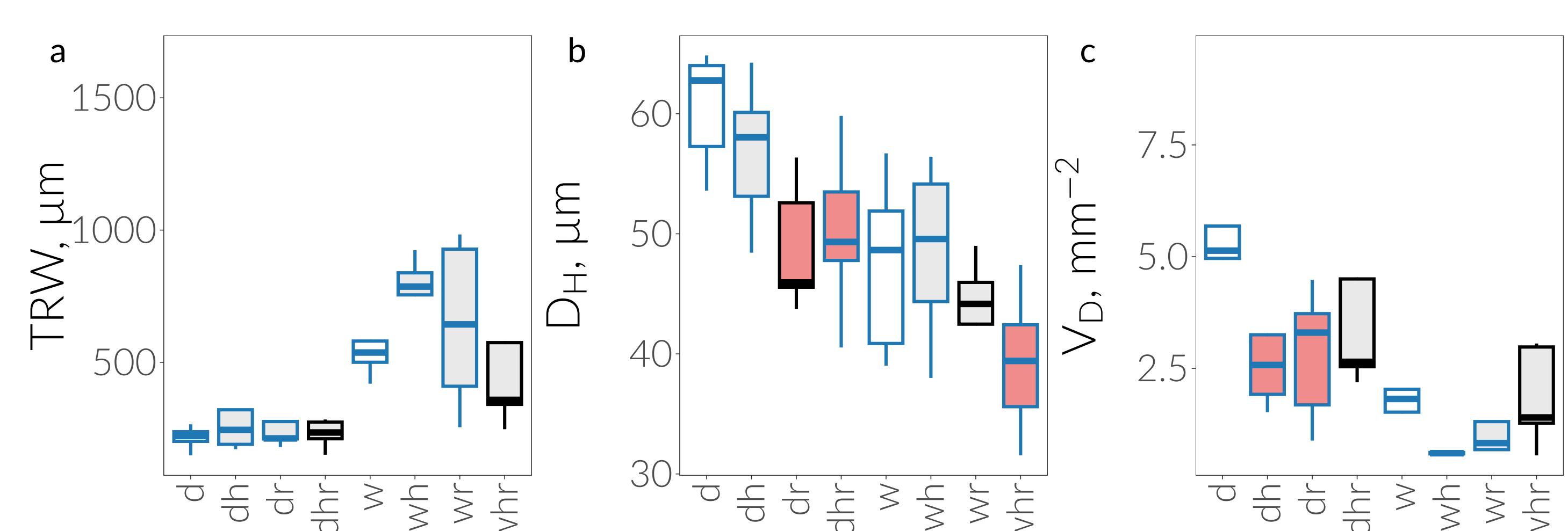


Figure 3. Xylem metrics of sessile oak xylem for the ring of 2022. a) tree-ring width, µm; b) hydraulic vessel diameter, µm; c) mean vessel area, µm²; black outline – treatment of dry (wet) variant is not sig. different from dry (wet) variant of the same treatment; blue outline – treatment of dry (wet) variant is sig. different from dry (wet) variant of the same treatment; White fill – dry (wet) variant without treatment; light grey fill – dry (wet) variant with treatment. No sig. difference from dry (wet) variant without treatment; red fill – dry (wet) variant with treatment. Sig. difference from dry (wet) variant without treatment. $\alpha = 0.1$

Norway spruce

Norway spruce didn't exhibit much change in xylem structure. Only dimensions of earlywood tracheids decreased in dry conditions with hydrogel application.

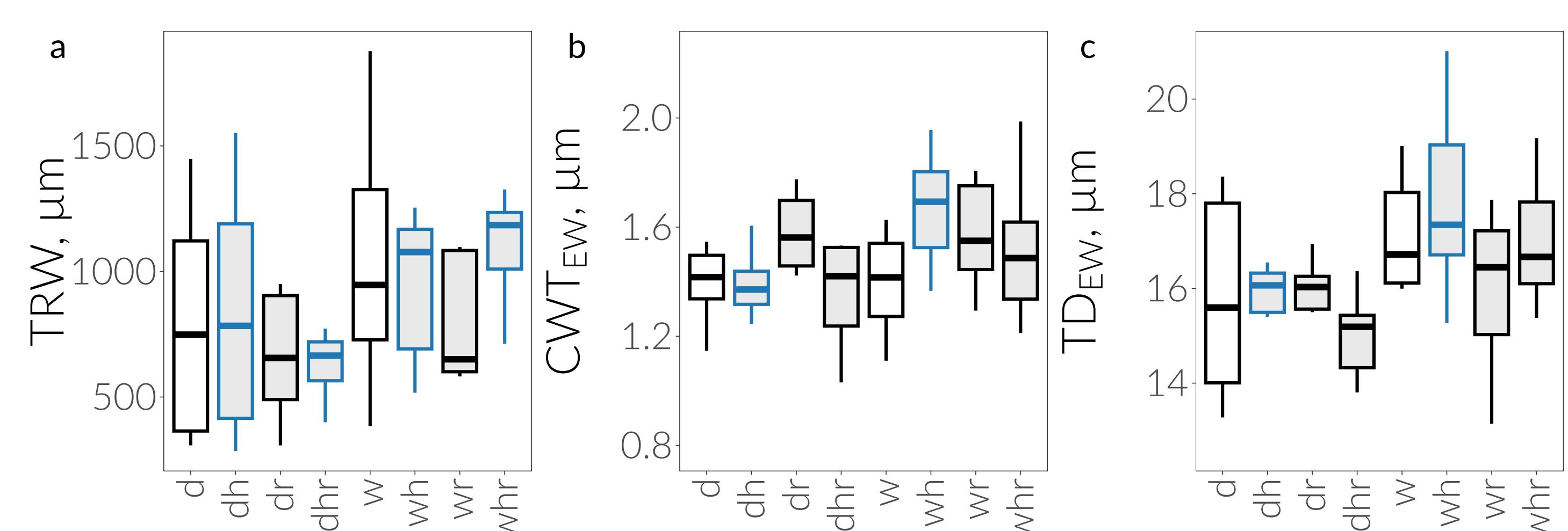


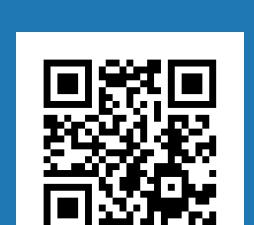
Figure 4. Xylem metrics of Norway spruce xylem for the ring of 2022. a) tree-ring width, µm; b) earlywood radial cell wall thickness, µm; c) earlywood radial tracheid diameter, µm; black outline – treatment of dry (wet) variant is not sig. different from dry (wet) variant of the same treatment; blue outline – treatment of dry (wet) variant is sig. different from dry (wet) variant of the same treatment; White fill – dry (wet) variant without treatment; light grey fill – dry (wet) variant with treatment. No sig. difference from dry (wet) variant without treatment. $\alpha = 0.1$

Discussion

- After two years of artificial drought, species displayed contrasting plant hydraulic strategies. Sessile oak, unlike Norway spruce, reacted to dry conditions markedly.
- Crown reduction in dry conditions and its combination with hydrogel in both dry and wet conditions helped sessile oak to mitigate the effect of drought by lowering vessel diameter. Additionally, sessile oak reacted to crown reduction in dry conditions and to hydrogel in both dry and wet conditions by lowering vessel density.
- For Norway spruce, neither drought nor treatments had any effect. Despite in dry conditions with hydrogel Norway spruce had lower than in wet conditions tree-ring width, cell wall thickness and tracheid diameter of earlywood tracheids, hydrogel itself did not reduce the effect of drought.

Acknowledgements

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TEX & R code in git repo

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