

Transient tensile and compressive strains differentially modulate wood formation

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Context and objective

Trees constantly experience wind, perceive resulting mechanical cues, and modify their growth and development accordingly. Previous studies, mainly in gymnosperms, have demonstrated that multiple bendings mimicking the effect of wind trigger ovalization of the stem and the formation of a special type of reaction wood called flexure wood (Telewski 2016). Very few studies on ovalization and flexure wood relate to angiosperm trees, and all the experiments conducted so far have used multidirectional bendings of uncontrolled intensities. Assuming bending is composed of tensile and compressive strain, we hypothesized that different local strains may generate specific growth and wood differentiation responses.

Material and methods

To assess this hypothesis, multiple quantified flexural strains were applied to young *Populus* stems. This was achieved using unidirectional bendings; thereby a given cell is experiencing always strains of the same sign (longitudinal compression or longitudinal tension only), allowing to distinguish the wood formed under tensile and compressive flexural strains. The different effects of bendings were characterized quantitatively studying radial growth, cell size and cell wall ultrastructure. Moreover, to gain a first molecular insight into how multiple bendings can modulate wood anatomical traits, we used a Q-PCR approach to investigate the expression of 4 target mechanosensitive genes known for their role in wood differentiation.

Results

In response to multiple unidirectional bendings, poplar stems developed a significant ovalization of their cross-section. At tissue level, some aspects of wood differentiation were similarly modulated by compressive and tensile strains (vessel frequency, diameter of fibres without G-layer), whereas other anatomical traits (vessel diameter, G-layer formation, diameter of fibres with G-layer, microfibril angle) and expression of fasciclin-encoding genes were differentially modulated by compressive and tensile strains. This work leads to the proposition of new terminologies to distinguish the “flexure wood” produced in response to multiple bidirectional bendings from wood produced under transient tensile strain (TSW) or under transient compressive strain (CSW). By highlighting similarities and differences between tension wood and TSW and by demonstrating that plants are able to discriminate positive strains from negative strains, this work brings new insights on the mechanisms of mechanosensitivity in plants.

References

Telewski, F. W. (2016). Flexure wood: mechanical stress induced secondary xylem formation. Chapter 5 In *Secondary Xylem Biology: Origins, Functions, and Applications*, 73-87. Ed. Kim, Y. S., Funada, R., & Adya, P. Academic Press.