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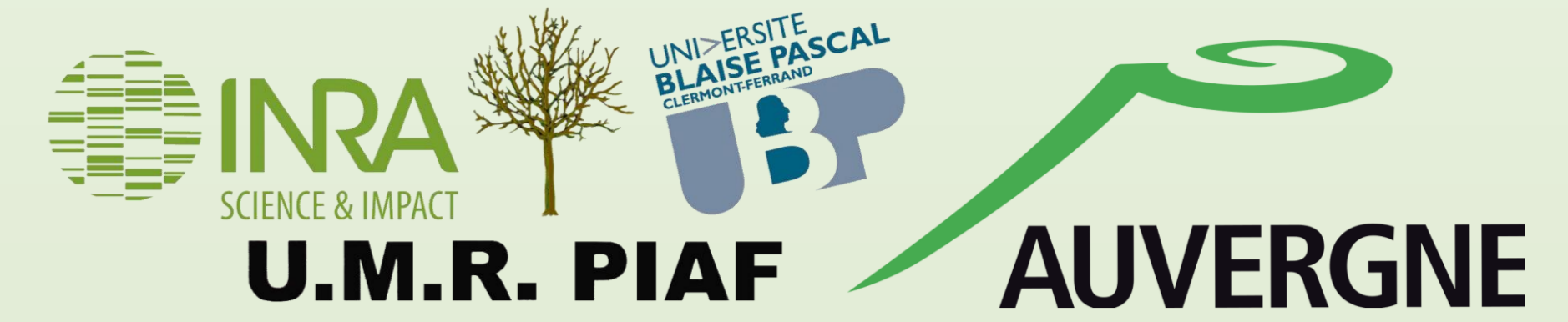
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Integrative Biomechanical Study of Flexure Wood Formation

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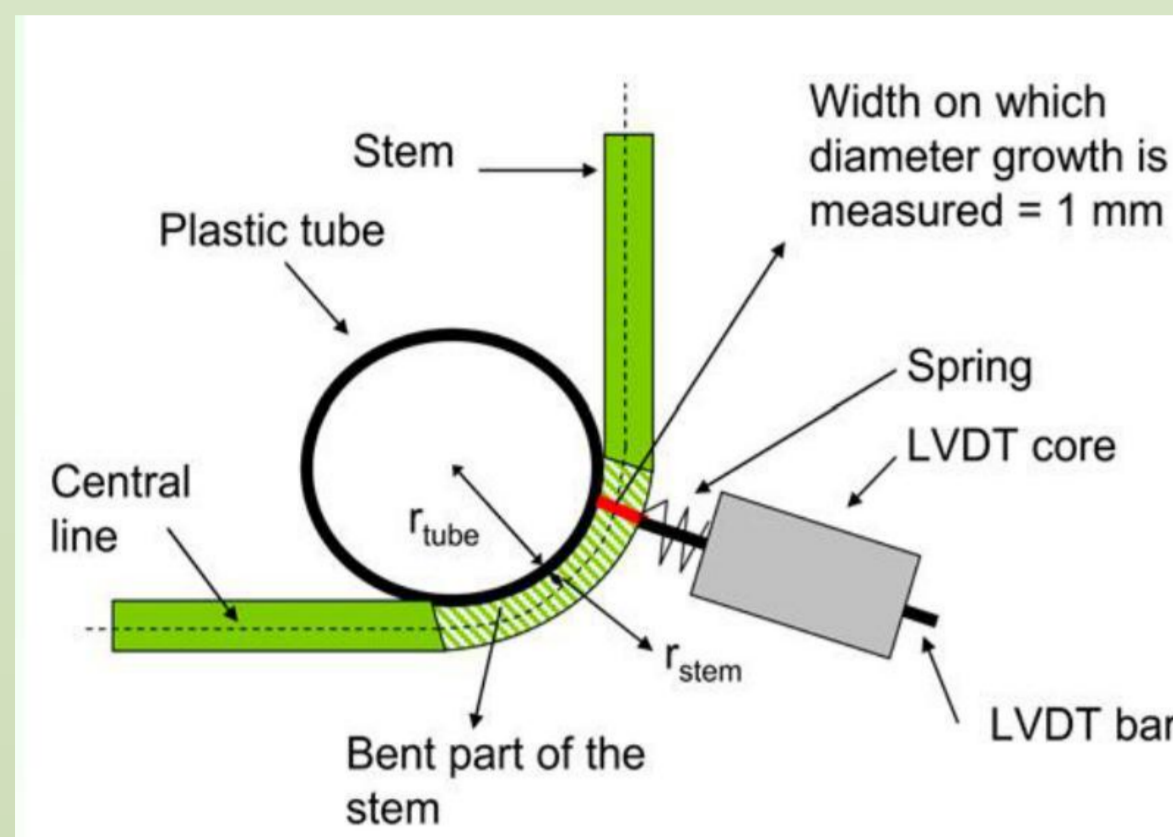
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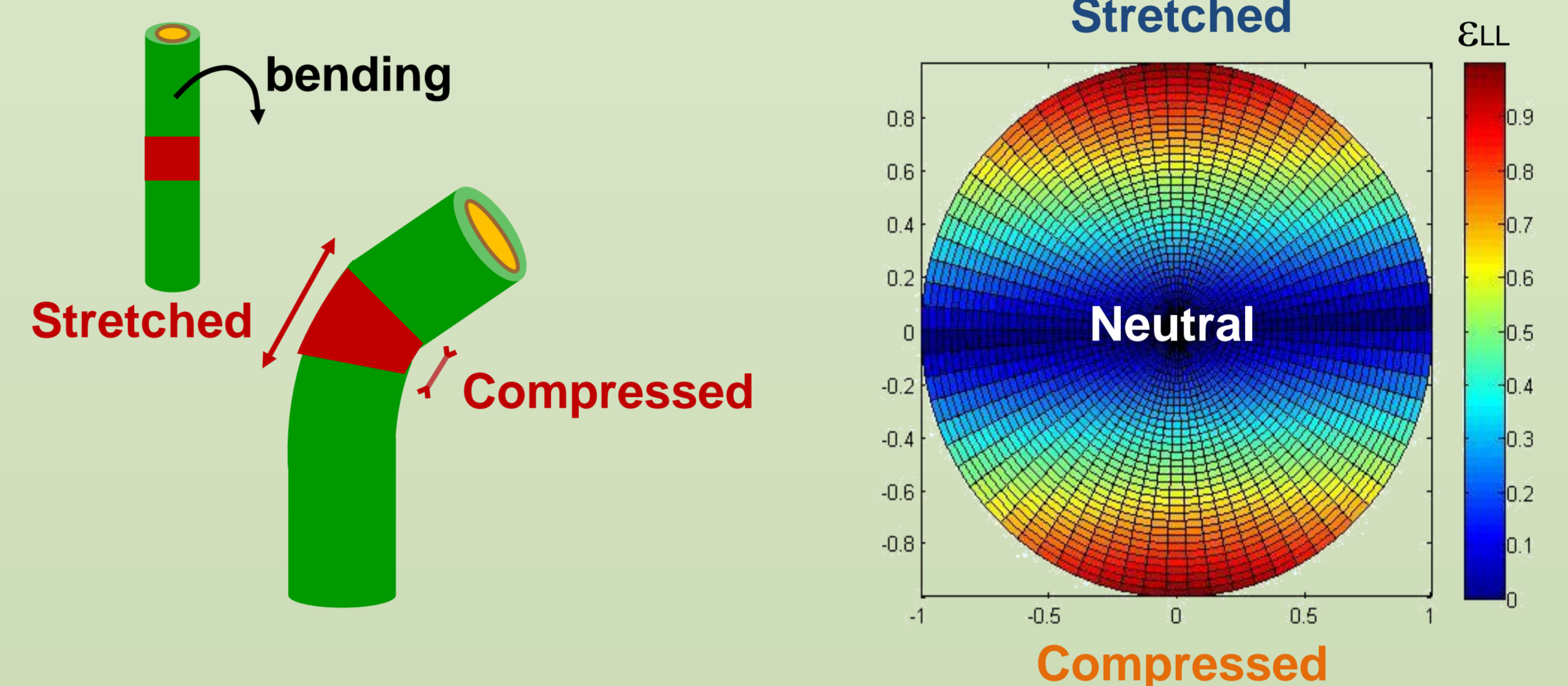
Introduction

Mechanical signals are important factors controlling plants growth and development. External mechanical loadings, such as wind, lead to a decrease of primary growth, an increase of secondary growth, modifications of stem mechanical properties and biomass reallocation to roots. The acclimation of trees to wind-induced physical constraints could originate from such growth modifications. Moreover, recent results showed that mechanical signals generate wood differentiation adjustments leading to the production of a wood presenting similarities with tension wood : the **Flexure Wood**. To have a better control over wood production and quality, it seems now important to gain a better understanding of how mechanical constraints modulate secondary growth and wood differentiation.



An integrative model of mechanosensing, the model S^3m (1) helped us to :

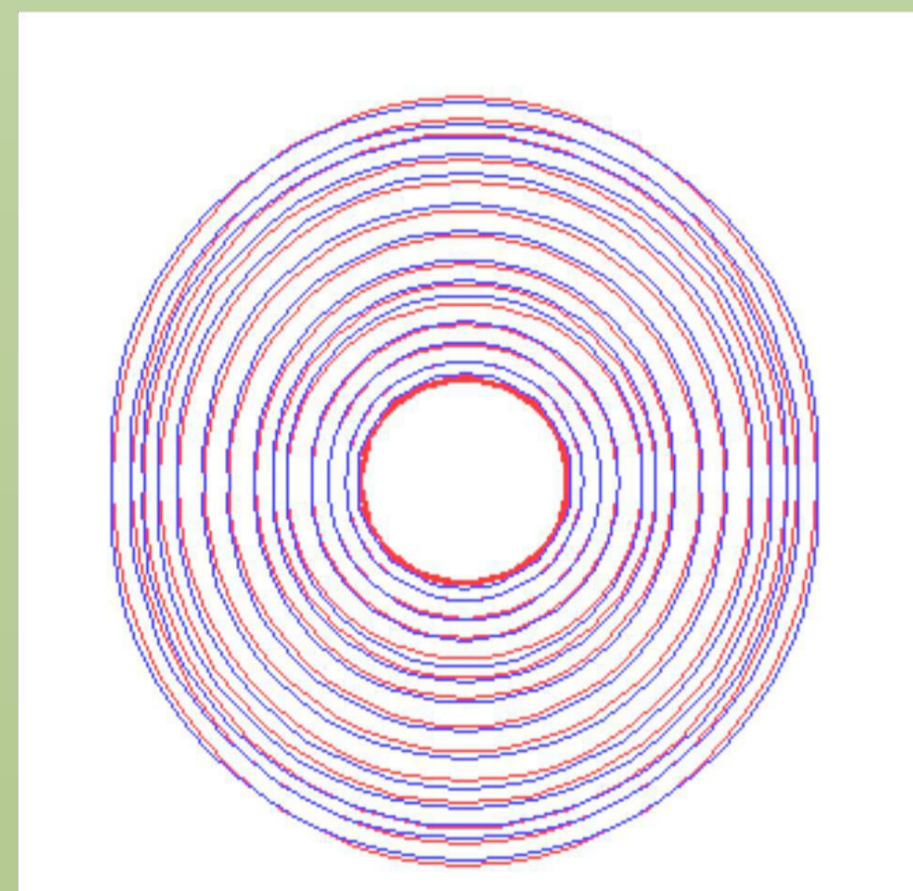
- show that plant cells are sensitive to strains
- develop a device which allows to quantify the level of longitudinal strains applied during a single stem bending (on the left)
- show that **global** stem diameter growth is correlated with the intensity of the sum of longitudinal strains (2)
- show that the strain in the stretched and the compressed zone is **equal** in absolute value, and the central zone of the stem, called neutral zone is a zone without strain (on the right).



Results

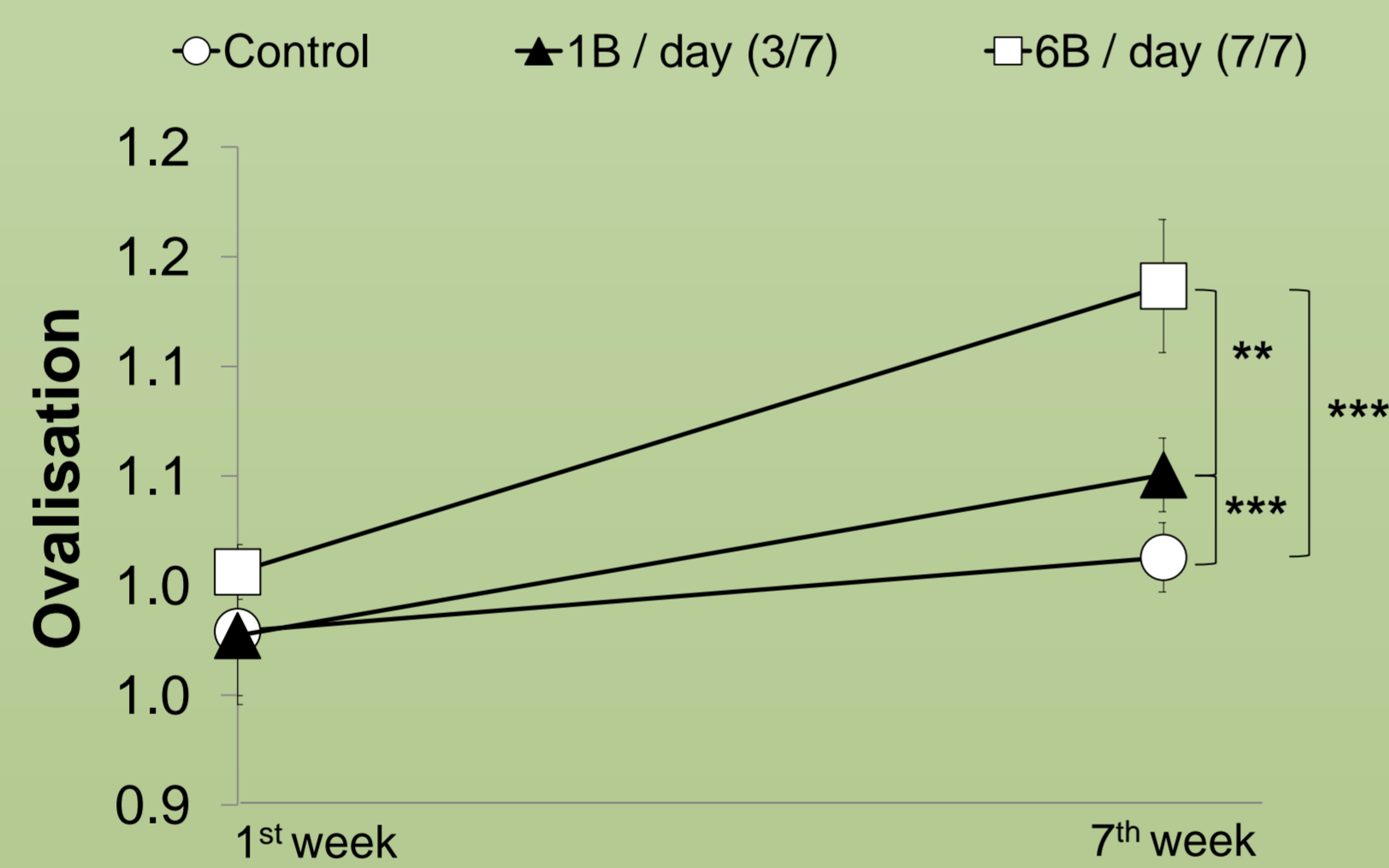
Secondary Growth

Study of the effect of strains on secondary growth at a more local scale (stem section scale)



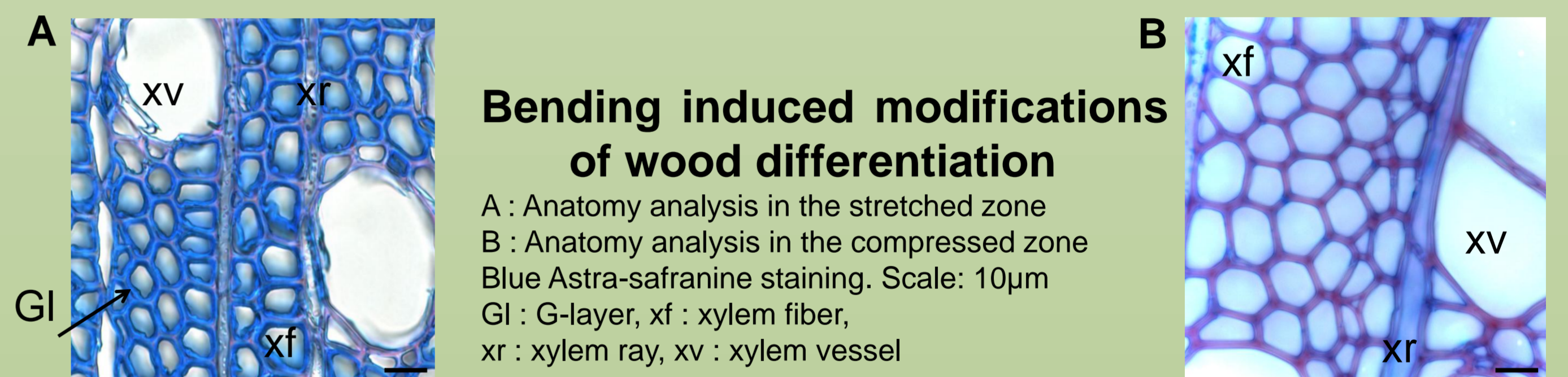
Weekly growth rate measurements (blue lines) and growth rate modeling (red lines)
 $\Delta R(i,t) = \Delta C(i,t)(1 + \alpha_{\epsilon_{LL}}(t))$

Effect of different bending regimes



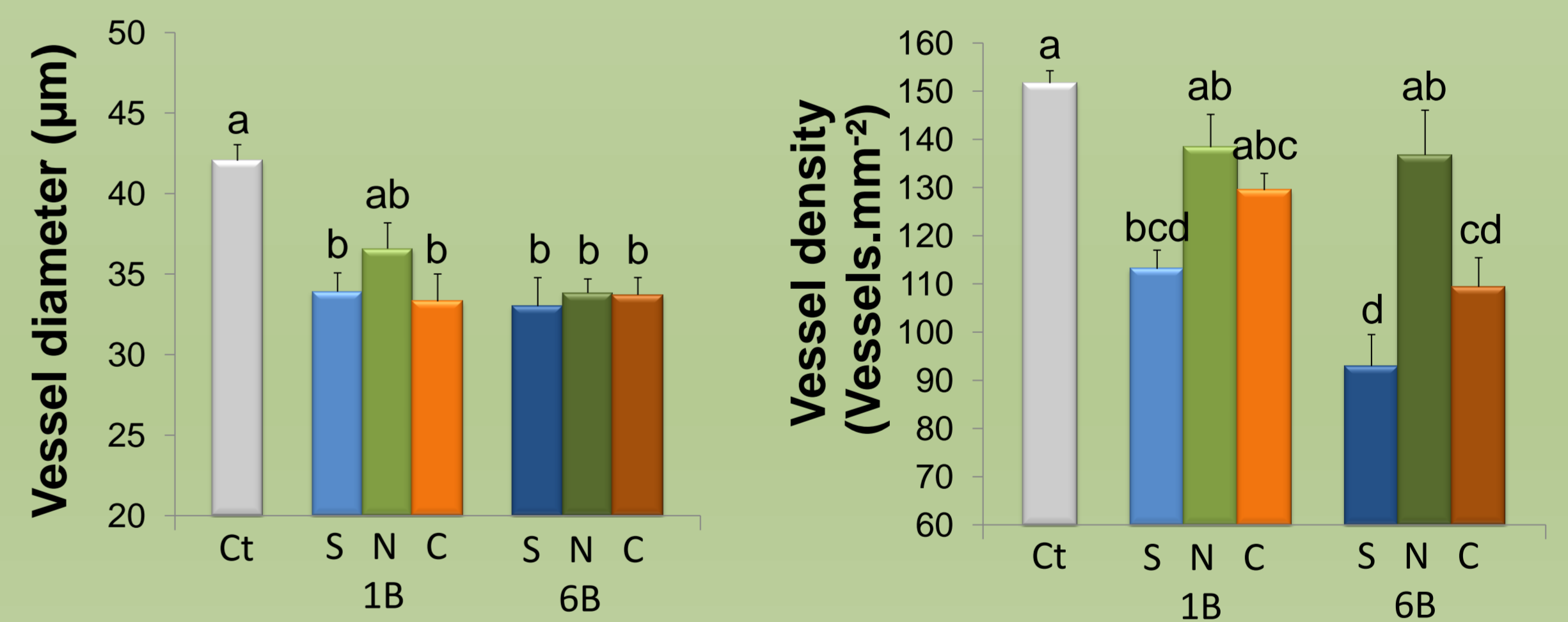
Open circle: Control, Triangles represent growth response to a regime of one bending a day (3days/7), Squares represent growth response to a regime of 6 repeated bending a day (7/7). Significant differences are indicated by asterisks (** : $p < 0.01$; *** $p < 0.001$).

Wood Anatomy Modifications



Bending induced modifications of wood differentiation

A : Anatomy analysis in the stretched zone
 B : Anatomy analysis in the compressed zone
 Blue Astra-safranine staining. Scale: 10µm
 Gl : G-layer, xf : xylem fiber, xr : xylem ray, xv : xylem vessel



Stem anatomical modifications induced by different bending regimes
 Vessel diameter and density in the different part of the stem

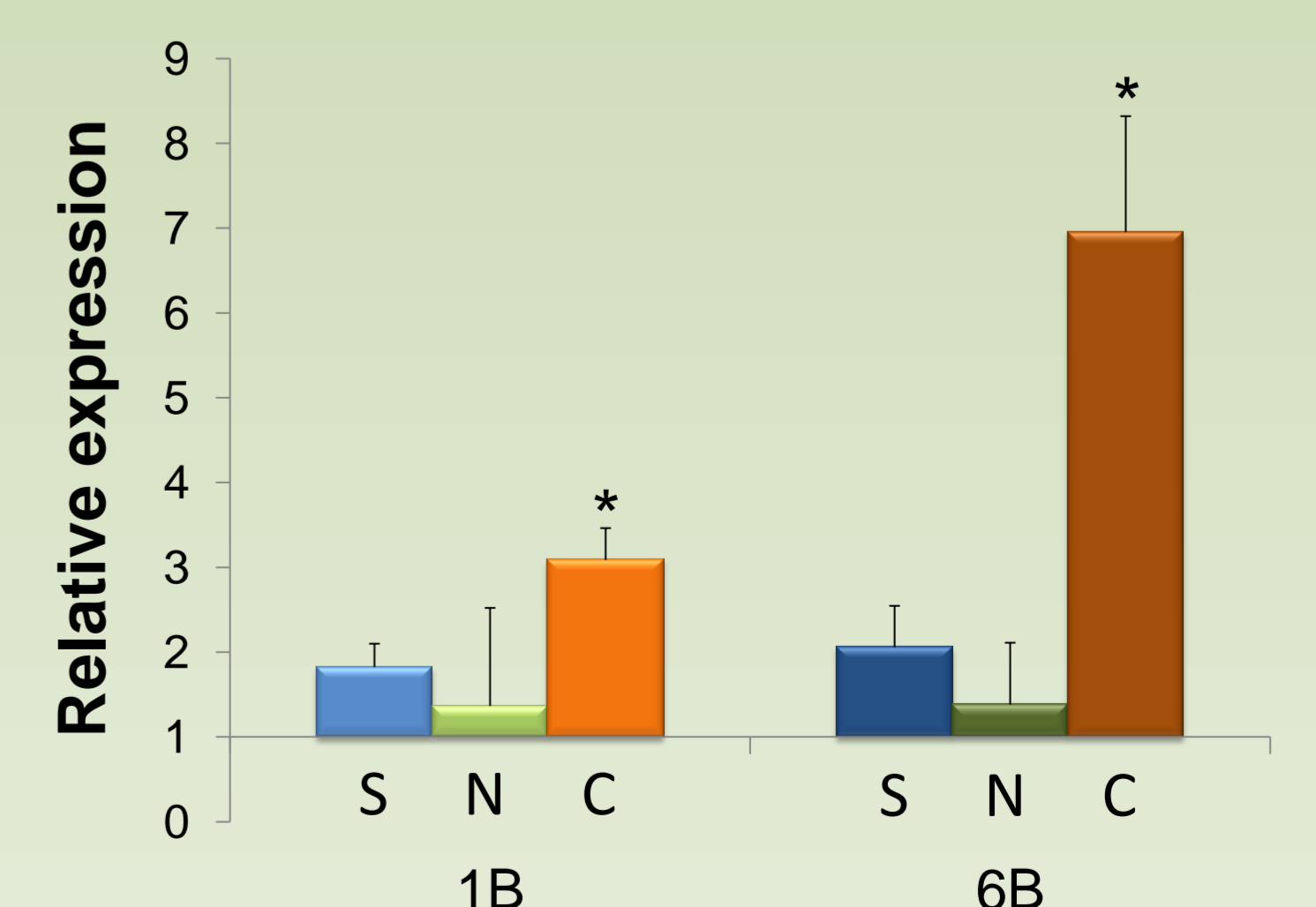
Ct: Control, S: Stretched zone, N: Neutral zone, C: Compressed zone
 1B: Plants subjected to one bending a day (3days/7) ; 6B: Plants subjected to 6 bending a day (7/7). Groups with the same letter are not significantly different ($p < 0.05$).

Conclusion

- ✓ Strains promote secondary growth and repeated bending accentuate the growth responses.
- ✓ There is a bending-induced decrease of vessels diameter and density.
- ✓ Although the intensity of strains is equal (in absolute value) in the stretched and compressed zone, there are **wood anatomy differences** between this two zones.

Perspectives

- Identification of molecular actors responsible for secondary growth and wood differentiation responses to bending, such as CLE-type peptide.
- Identification of physical factors responsible for wood differentiation differences.
- To detail our characterization of flexure wood (e.g. biochemical analysis).
- Modeling of the effect of different bending regime.



PtCLE12.2 expression in the different zone of the xylem after one (1B) or six (6B) bending (RT-qPCR).

Significant differences with the control are indicated by asterisks ($p < 0.05$).

References

- (1) Coutand, C. & Mouli, B. (2000) Biomechanical study of the effect of a controlled bending on tomato stem elongation: local strain sensing and spatial integration of the signal. *Journal of Experimental Botany*. 51 (352), pp. 1825–1842.
- (2) Coutand, C., Dupraz, C., Jaouen, G., Ploquin, S. & Adam, B. (2008) Mechanical Stimuli Regulate the Allocation of Biomass in Trees: Demonstration with Young *Prunus avium* Trees. *Annals of Botany*. 101 (9), pp. 1421–1432.