Mechanisms underlying gravitropic and autotropic recovery in poplar

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Introduction

Lodging is a major problem for herbaceous crops and young woody plants, causing significant yield losses. With climate change, the risk of severe storms during the growing season will increase. The risk of lodging will then be even greater.

Resilience is one of the strategies evolved by plants to cope with this problem. Resilience is the ability of plants to recover their structures and functions back to their reference states after disturbance. Resilience to lodging involves active movements called tropisms, *i.e.* a redirection of organs in the direction of or opposite to the physical stimuli. Our study focuses on gravitropism and autotropism. A fine-tuned combination of these two tropisms is required for the postural control of plants.

This relies on two perceptive abilities: i) graviperception (more exactly gravi-cline perception) for the perception of orientation with respect to gravity and ii) proprioception for the perception by the plant of its own curvature. Under the control of these perceptions, the plants activate motors that carry out movements. These motors can be differential elongation in primary growing zone and tension wood formation in secondary growing zone.

To understand resilience to lodging, we therefore study in this thesis the graviperceptive and proprioceptive sensitivities (with a greater focus on the latter, which is less well known), and the motors of the different movements related to these tropisms. In particular, we test the relevance of a universal model of postural control called the AC model (Moulia et al. 2021).

Materials and Methods

Methods: 1

1- Study the curving and straightening movements

2- Quantify the graviperceptive and proprioceptive sensitivities

3- Correlate these stem movements with anatomical changes involved in the motor activity

An original Experimental device 2

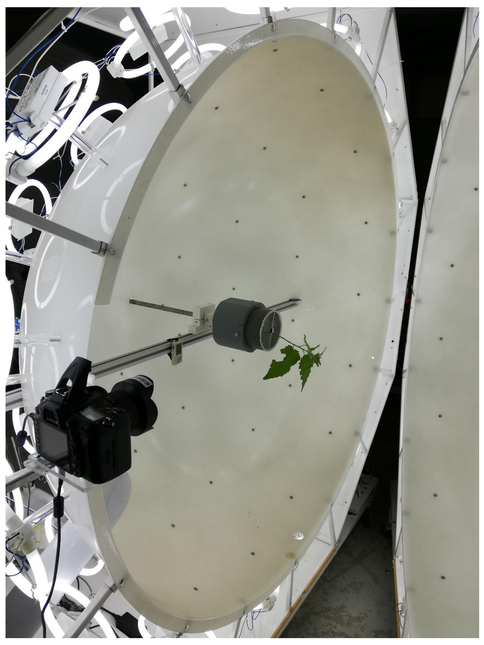
- **Isotropic lighting** = No phototropism
- **Clinostat (Rotation)** = Suspends graviperception
  ↳ Separation of graviperception and proprioception

- **Model-assisted phenotyping** : AC model (posture control explained by the perception of the inclination with respect to gravity (graviperception) and the perception of curvatures (proprioception))

Approaches used : 3

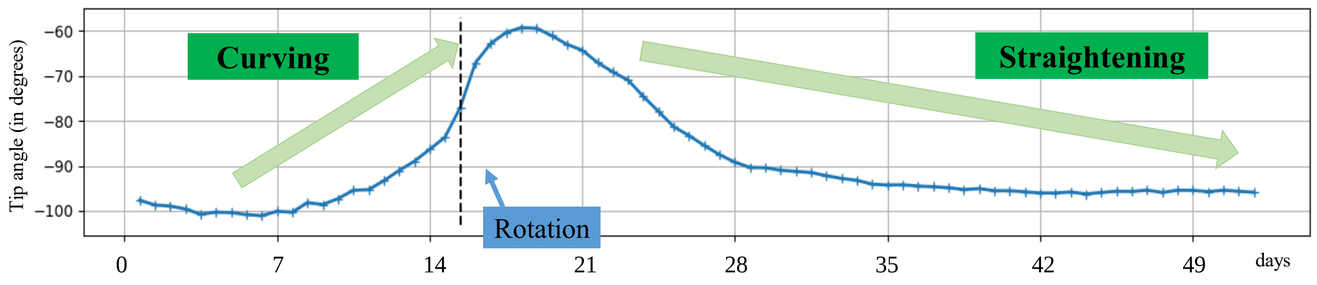
- Kinematic quantification of motion by image analysis, and estimation of AC model sensitivity parameters (Interekt software)

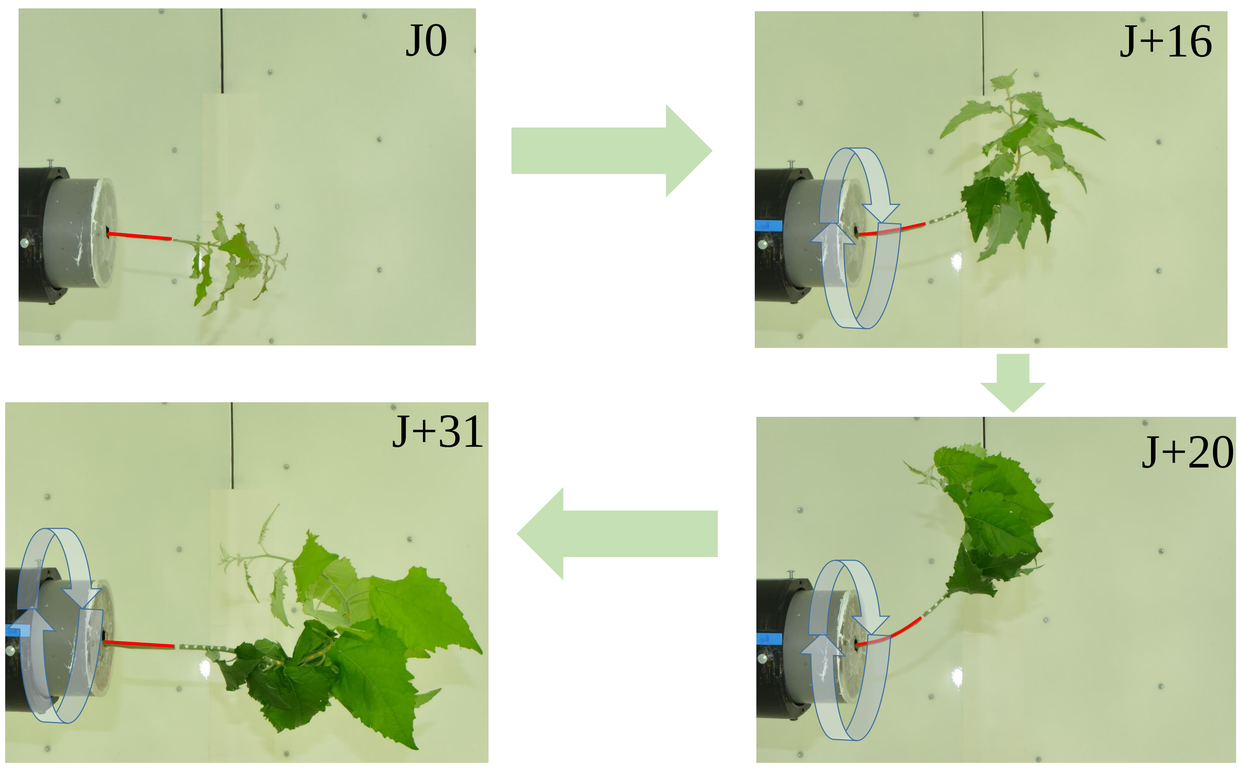
- Anatomical and cytological analyses of tension wood



Results

Part I: Sensitivity and motion control

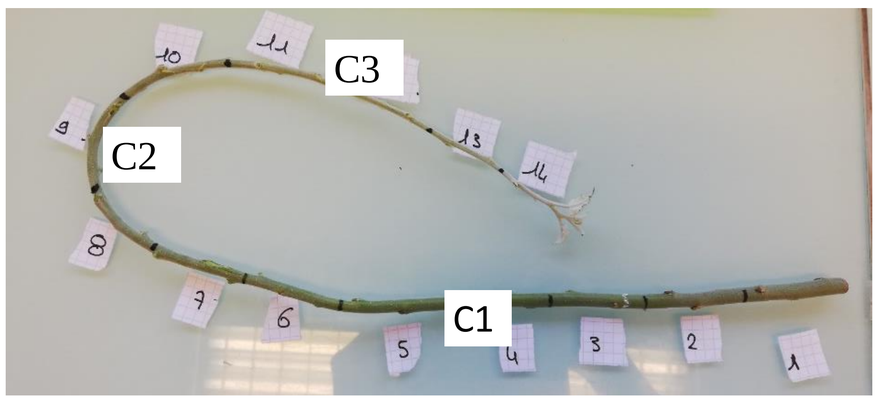


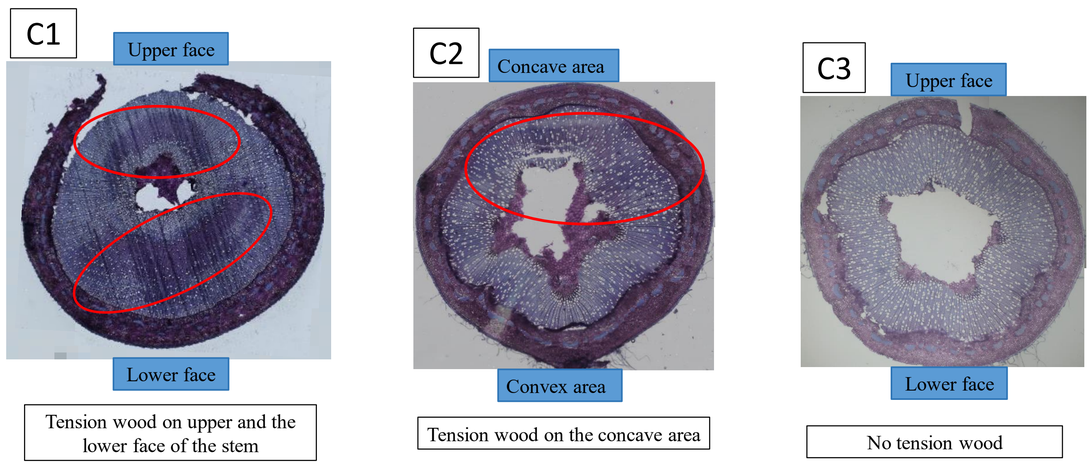


- Validated method used to track plant movements. AC model validated for the woody part

- Allows to have a sampling scheme (choice of the zones to be taken) for the anatomical/cytological/hormonal studies

Part II: Motricity (Movement motors)





- In the woody zone: Formation of tension wood for curving and straightening movements
- Unexpected result: steady curvature in the C2 zone, curved after the starting of clino-rotation and production of tension wood continuously on one side only : no proprioception in these tissues ?

Conclusion (up to now)

- Graviperceptive and proprioceptive sensitivities can be measured
- Tension wood : a movement motor linked to gravitropism and autotropism (control by proprioception)

❖ MOULIA B., DOUADY S. AND HAMANT O., 2021 Fluctuations shape plants through proprioception. *Science* 372, eabc6868 doi: 10.1126/science.abc686