Stem Bending generates electrical response in poplar.

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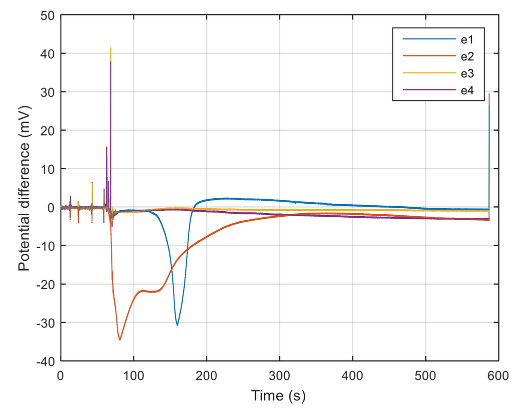
Introduction

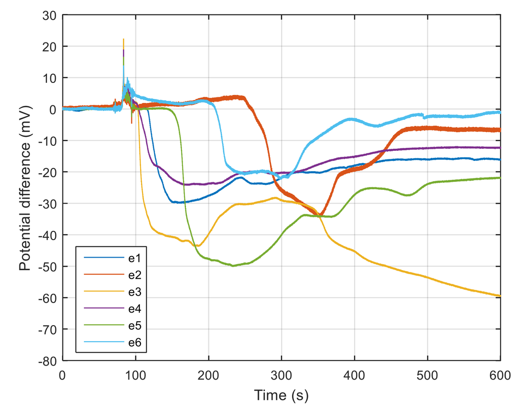
Under natural conditions, plants experience external mechanical stresses such as wind and touch that impact their growth. A remarkable feature of this mechanically-induced growth response is that it may occur at a distance from the stimulation site, suggesting the existence of a signal propagating through the plant. What is the vector of information that passes through the plant ? Three hypothesis on the nature of the signal are considered : chemical, hydraulic (Lopez et *al.*, 2014; Louf et *al.*, 2017) and electrical.

The objective of this study is to characterize the electrical response to poplar stem bending.

In plants, two electrical signals have already been described: i) the "slow wave" following an injury, and ii) the plant "action potential" following a thermal shock, an electrical stimulation, or to touch in motor plants (Krol et *al.*, 2010).

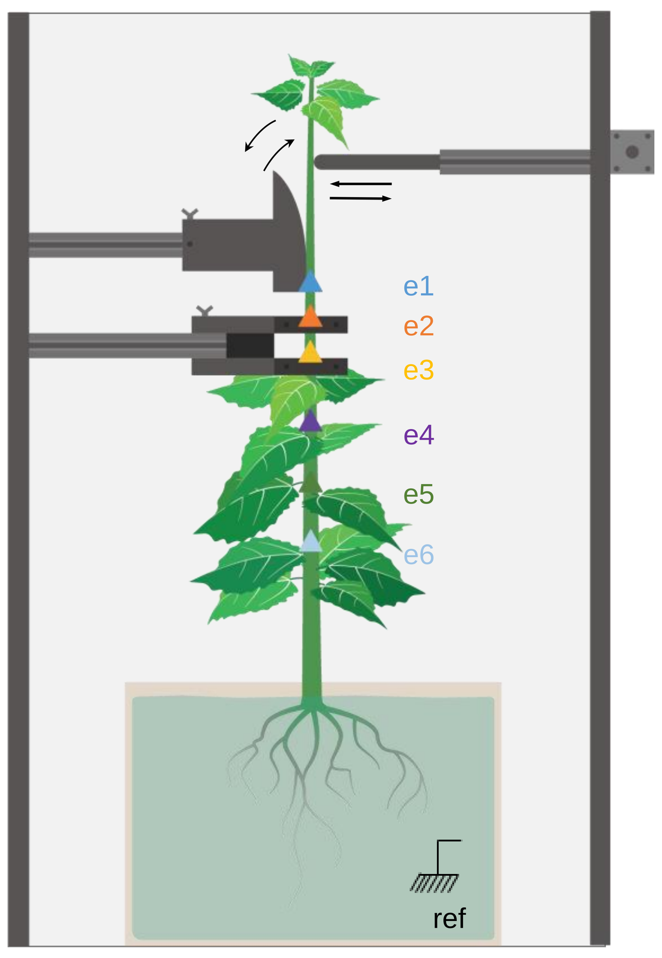


Plant action potential

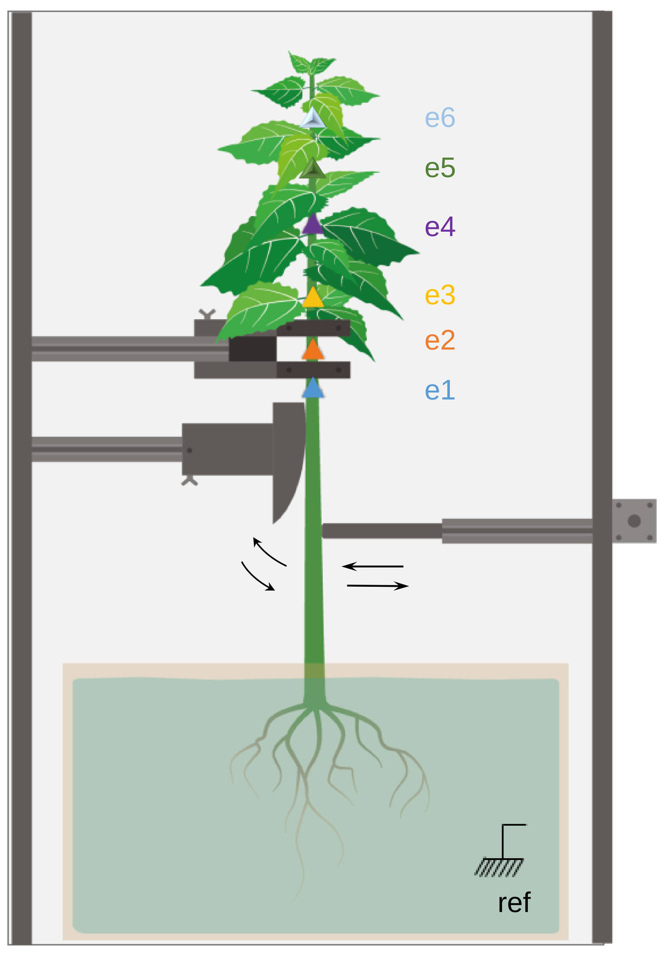


Slow wave

Materials and methods



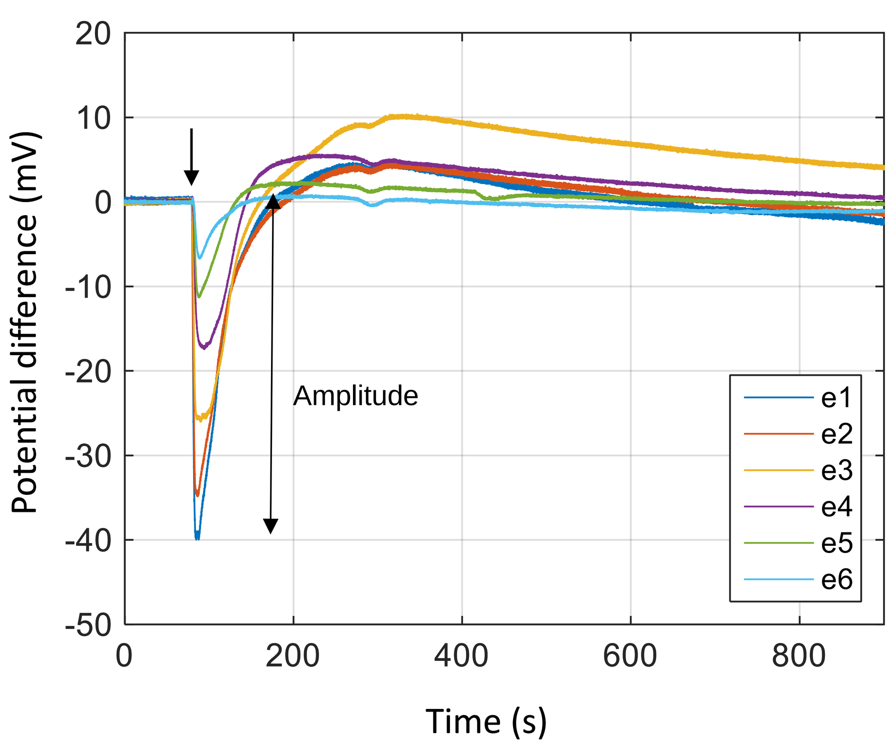
In a Faraday cage, poplars 70 cm tall are suspended in a nutrient solution. Six measuring electrodes are inserted in the immobile part of the stem and the reference electrode is placed in the solution. The electrical potential recorded is the difference between a measuring electrode and the reference electrode with respect to the ground. In contrast to intracellular measurements, extracellular measurements show potential changes downward for depolarization and upward for hyperpolarization.

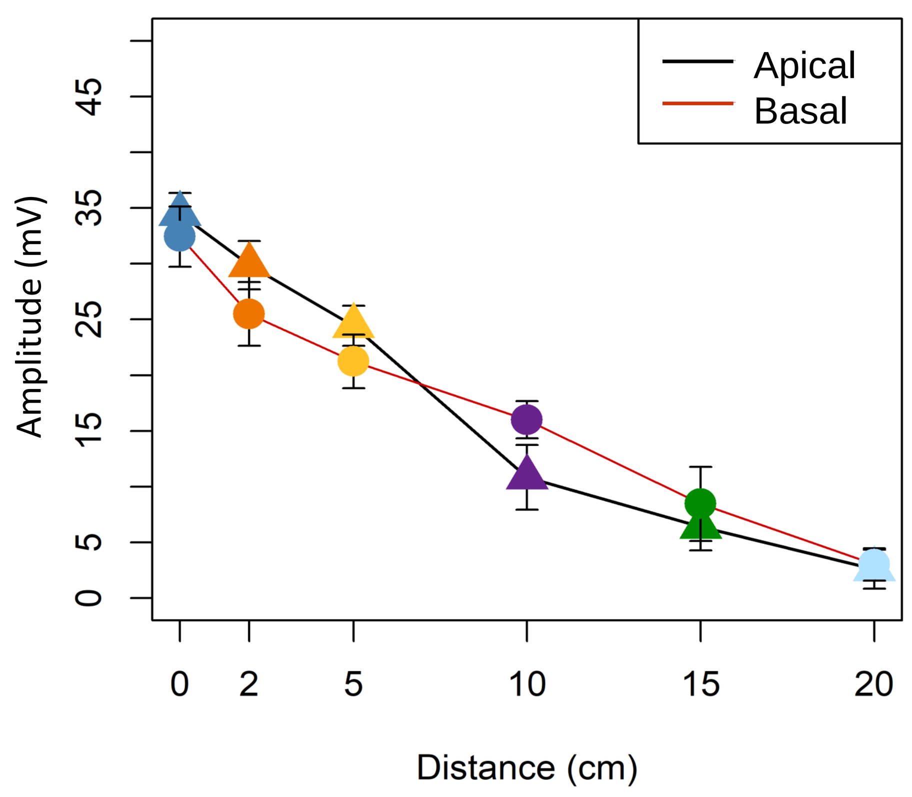


The speed and the magnitude of the bending stimulation were controlled by a motorized arm that pushed the stem against a plastic template, which had a constant radius of curvature. The setup was adjusted to apply a maximal peripheral longitudinal strain of the bark ε_{max} of around 2% (Coutand *et al.*, 2009). This method allowed applying the same strain level along 12 cm of the bent segment.

Two types of bending treatments were applied : apical bending and basal bending.

Results





Interval from the bent-zone (cm)	Average speed ($cm.s^{-1}$)	
	Apical bending	Basal bending
[0;2]	12.98 ± 2.4	15.12 ± 5.4
[2;5]	19.41 ± 3.8	16.87 ± 2.7
[5;10]	5.85 ± 1.7	12.27 ± 2.7
[10;15]	3.31 ± 1.7	8.43 ± 1.1
[15;20]	3.36 ± 2.7	1.19 ± 1.2

SIGNAL'S AMPLITUDE

A single, transient and rapid bending (2s) of the apical part of the poplar stem induced a depolarization wave propagating basipetally up to 20 cm with a significant decrement. The mean amplitude near the flexion point was around 34 mV (e1), and dropped to 24 mV after 5 cm (e3), to reach a mean close to zero at 20 cm (e6 = 2.6 mV). The passage of the depolarization wave was followed by a slight hyperpolarization of the four measuring electrodes closest to the stimulation.

SIGNAL'S VELOCITY

The average propagation speed of the depolarization wave was evaluated between each electrode. Close to the bent zone, the speed ranged from 12.9 to 19.4 $cm.s^{-1}$ between e1 and e3, while it dropped significantly to a range of 5.8 to 3.3 $cm.s^{-1}$ between the farthest electrodes e3 and e6. Triggering and propagation of the electrical signal in response to stem apical bending was found in 100 % of poplars (n= 10).

STEM BENDING

Basal bending of the stem generates an acropetally propagating depolarization wave with similar characteristics in amplitude and velocity as that generated by apical bending.

COMPARAISON WITH ACTION POTENTIAL

Signal's characteristics	Action potential	Bending response
Amplitude attenuation	None	Yes
Velocity	0,5 cm/s	1 à 20 cm/s
Velocity attenuation	None	Yes

Conclusion & perspectives

Conclusion:

- Stem bending was found to cause an electrical response we called 'gradual' potential, similar in shape to an action potential.
- However, this signal can be distinguished from the well-known plant action potential by its propagation up to 20 cm along the stem and its strong dumping in velocity and amplitude.

Perspectives:

- Testing the hypothesis of hydro-electric coupling (Julien 1993; Farmer et *al.*, 2014).
- To determine whether bending-induced electrical response is likely to trigger a molecular response locally and/or at a distance from the stressed area.

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