Aquaporin TIP1 expression and its regulation in the growing root apex under two levels of osmotic stress

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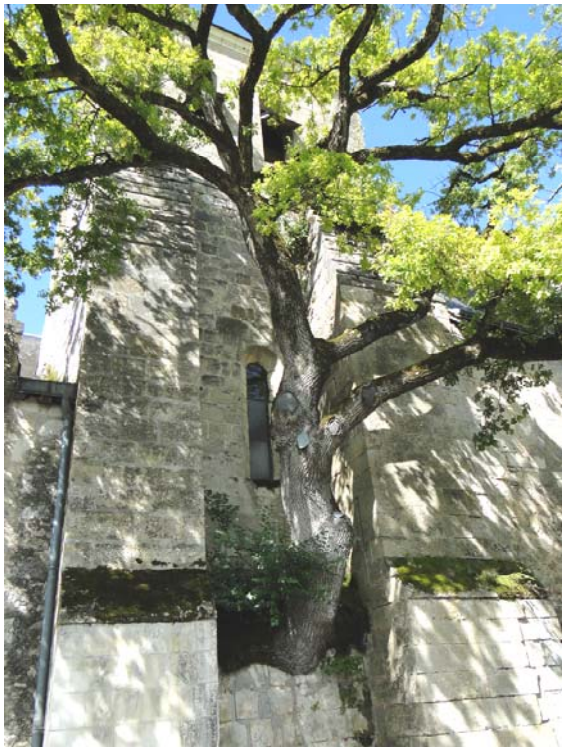
ROOT 2011

Aquaporin *TIP1s* expression and their regulation in the growing root apex under two levels of osmotic stress

Nancy-Université
Université Henri Poincaré

INRA

Université Blaise Pascal



Roots

- anchor plants
- uptake water and nutrients

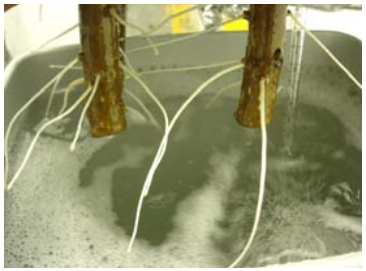
Under drought, growth of roots

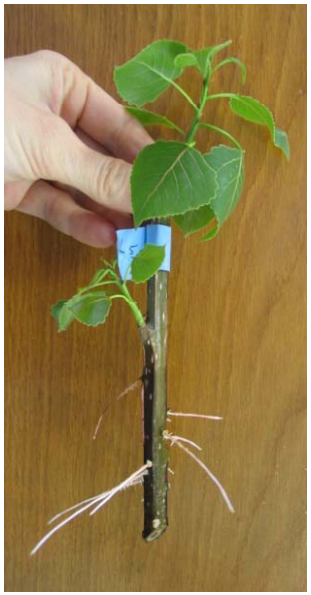
- allows the prospection of distant and wetter soil horizons
- contributes to plant acclimation and tolerance to water deficit

↳ Control of root growth under water deficit ?

Populus deltoïdes x nigra cv Soligo

Cuttings grown in hydroponics





Root growth under osmotic stress

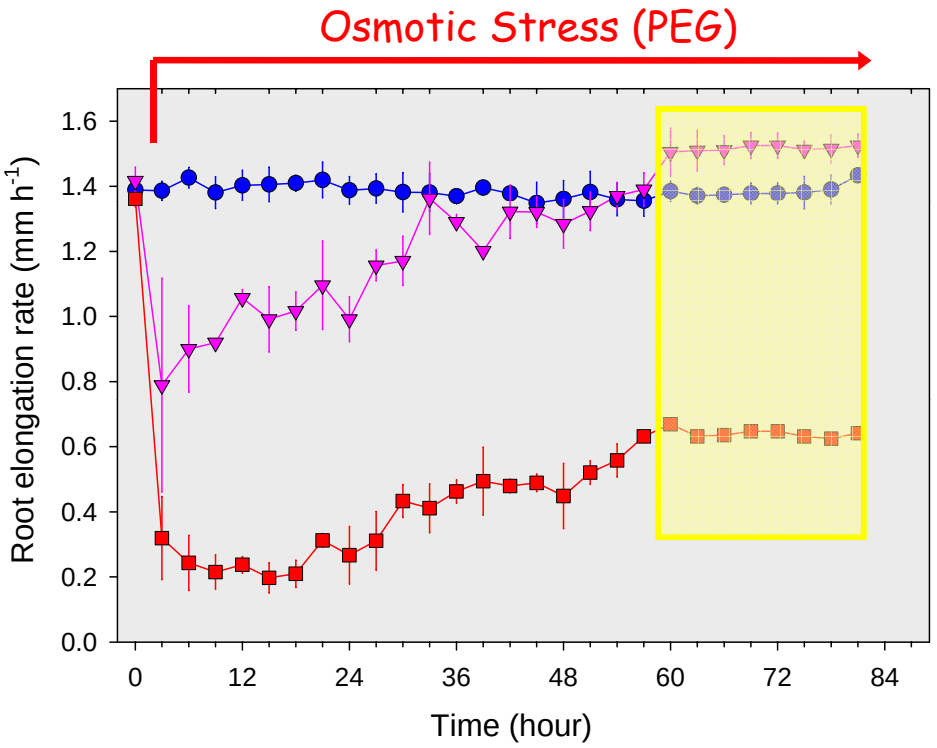
21°C, continuous dark

- Control

2 levels of continuous and stable osmotic stress (PEG 3350 g mol^{-1}) :

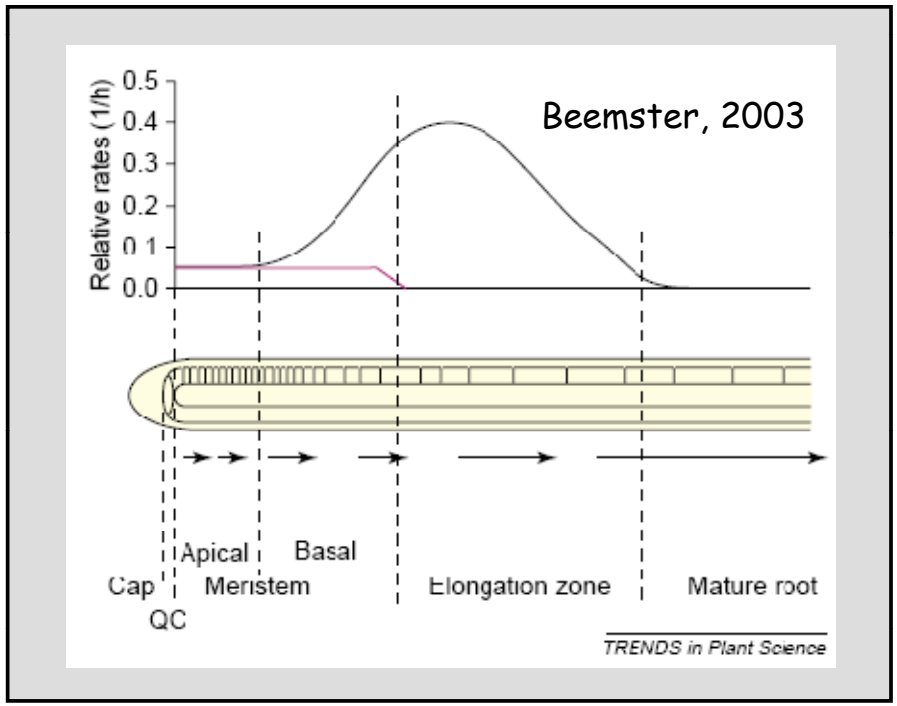
- Moderate stress :
(90 mosmol kg^{-1} , 100g L^{-1} PEG)

- High stress :
(260 mosmol kg^{-1} , 200g L^{-1} PEG)

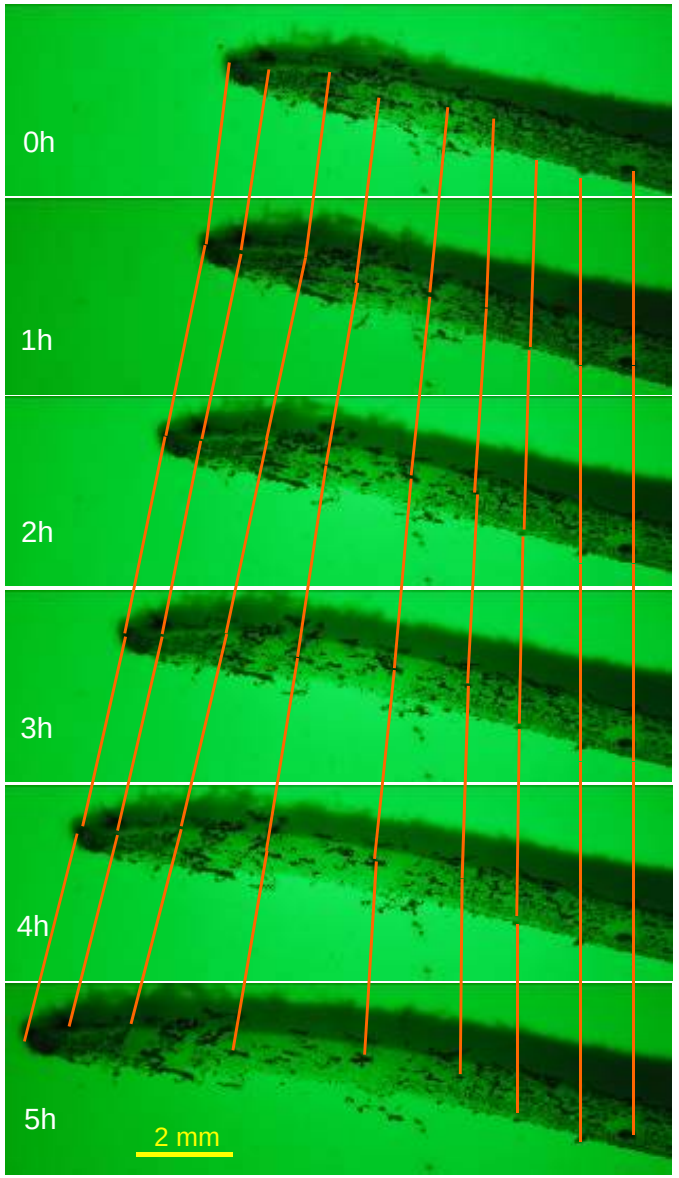


- steady state
- 3 contrasted elongation rates
  - control
  - moderate stress : sightly higher than control
  - high stress : lower than control

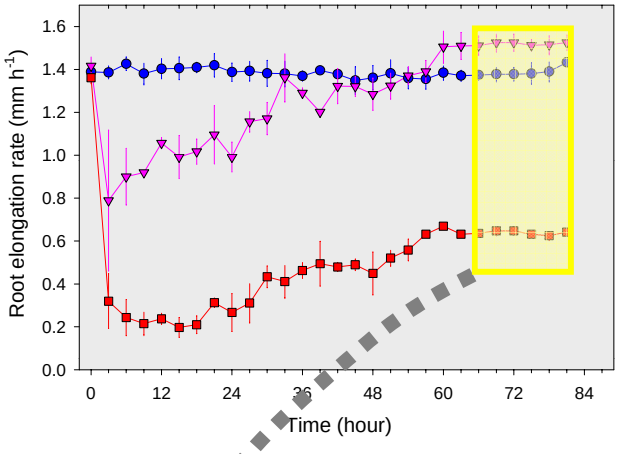
Root elongation results from cell division and cell expansion

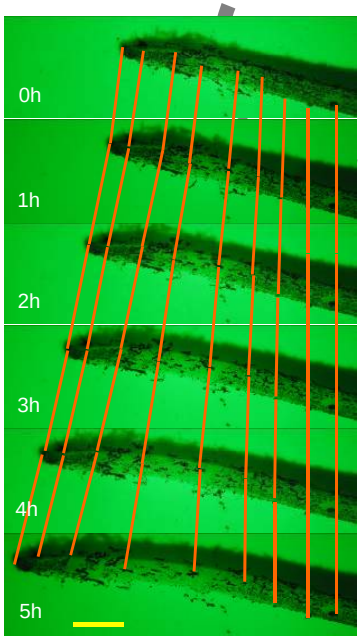


Carbon particles deposition & *in vivo* time laps photography



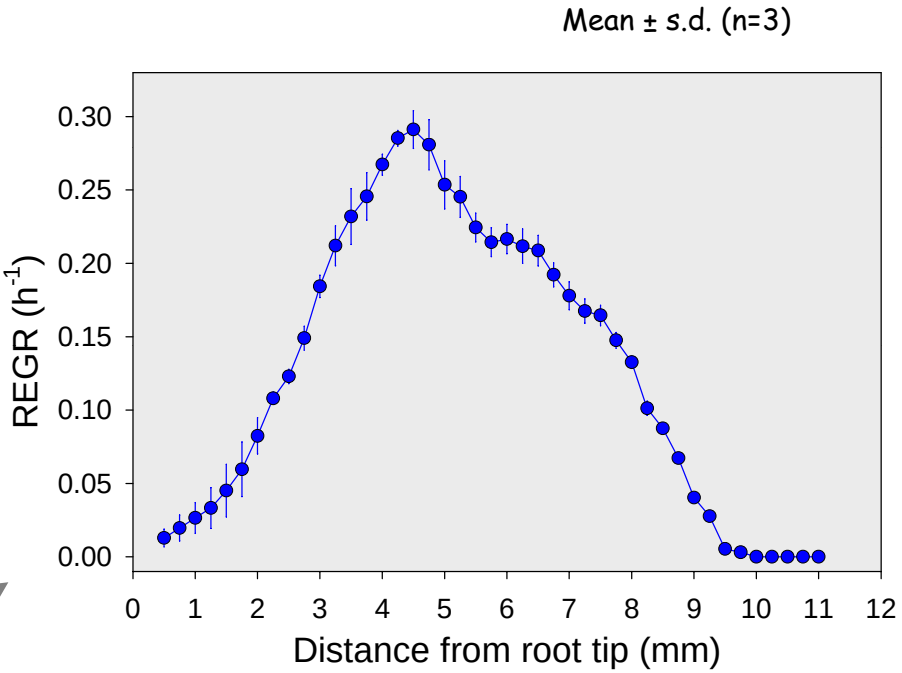
Relative Elemental Growth Rate



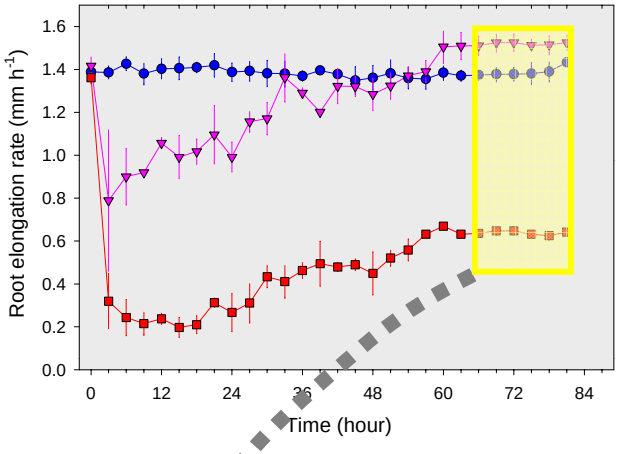


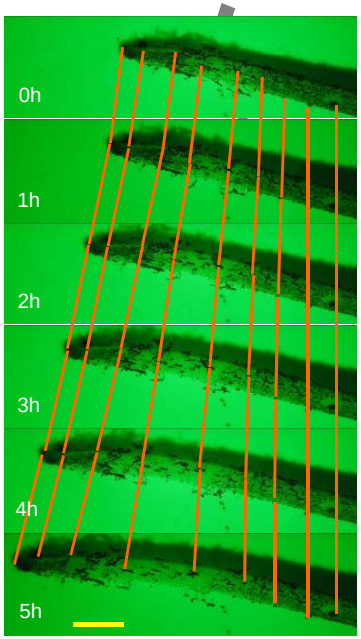
kinematic analysis

Kineroot
(Basu et al, 2007)



Relative Elemental Growth Rate





kinematic analysis

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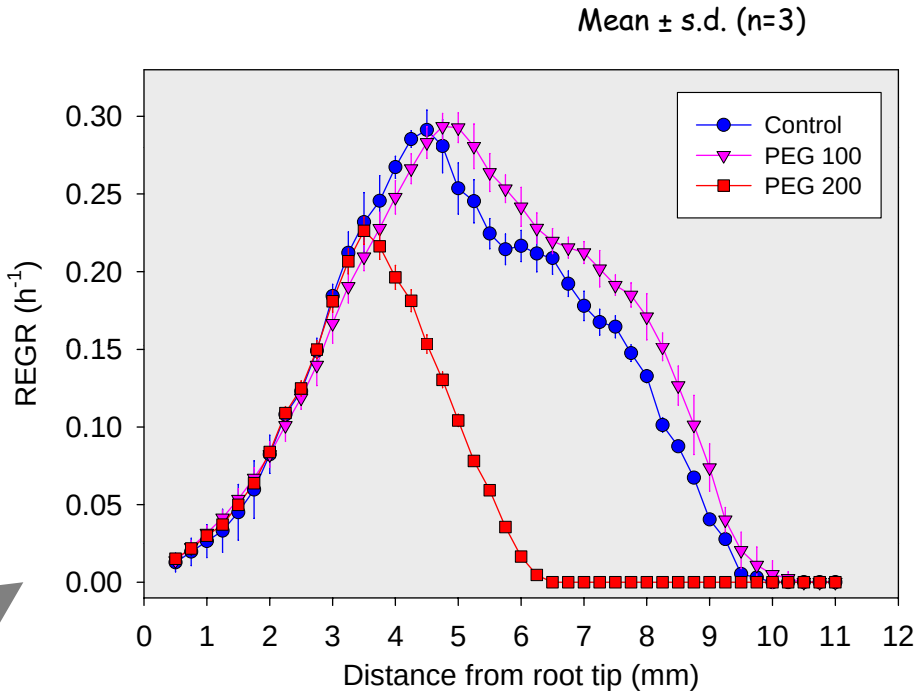
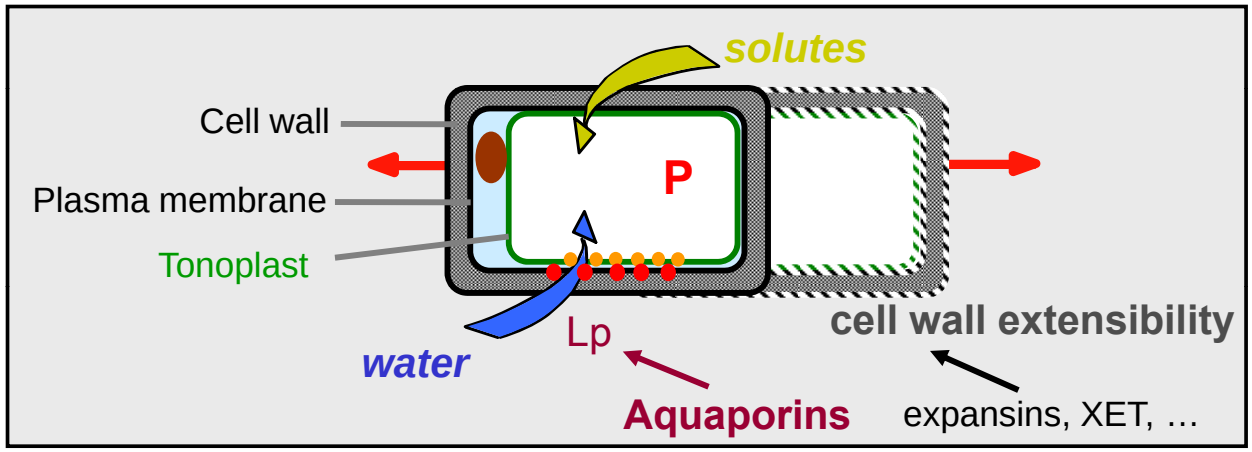


- REGR differentially affected along the growth zone
- Cell expansion rate differentially affected

Are growth alterations due to variations of hydraulic conductivity ?

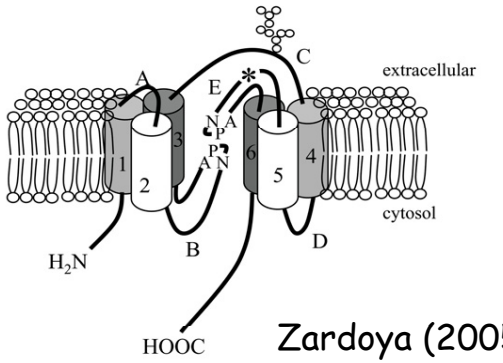
Biophysical model of cell expansion (Lockhart, 1965) :

$$\frac{1}{V}\cdot\frac{dV}{dt} = \frac{L\,\phi}{L+\phi}\cdot(P-Y)$$

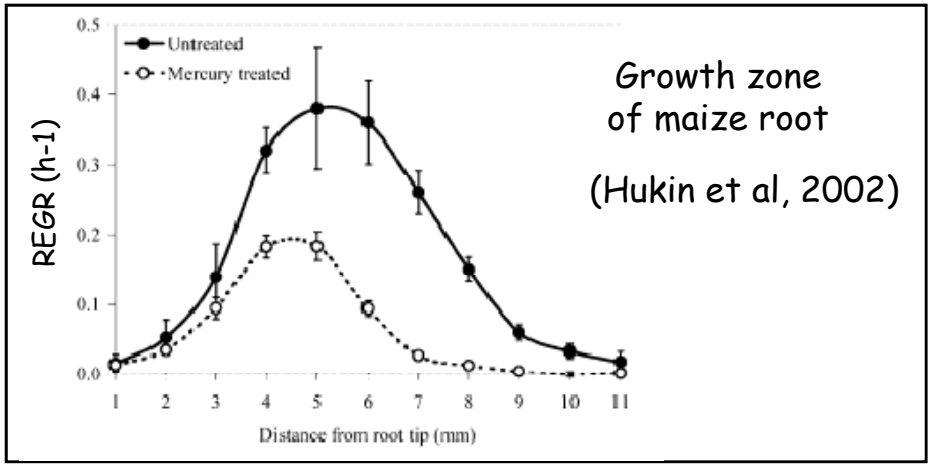


Hydraulic limitation of cell expansion (Cosgrove, 1993; Boyer & Silk, 2004)

↳ Involvement of aquaporins ?



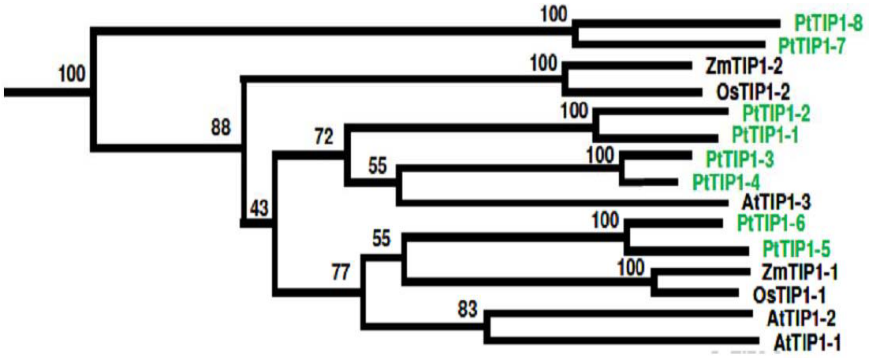
Zardoya (2005)



Aquaporin family : several classes

- PIP : Plasma membrane intrinsic protein
- TIP : Tonoplast intrinsic protein

& NIP, SIP, XIP …



Gupta and Sankaramakrishnan, 2009

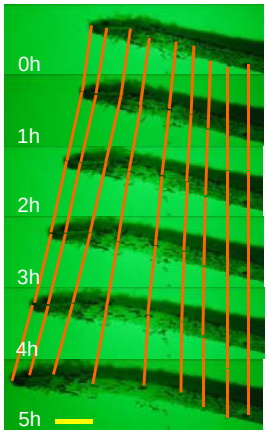
Pt : *Populus trichocarpa*
Os : *Oryza sativa*
At : *Arabidopsis thaliana*
Zm : *Zea mays*

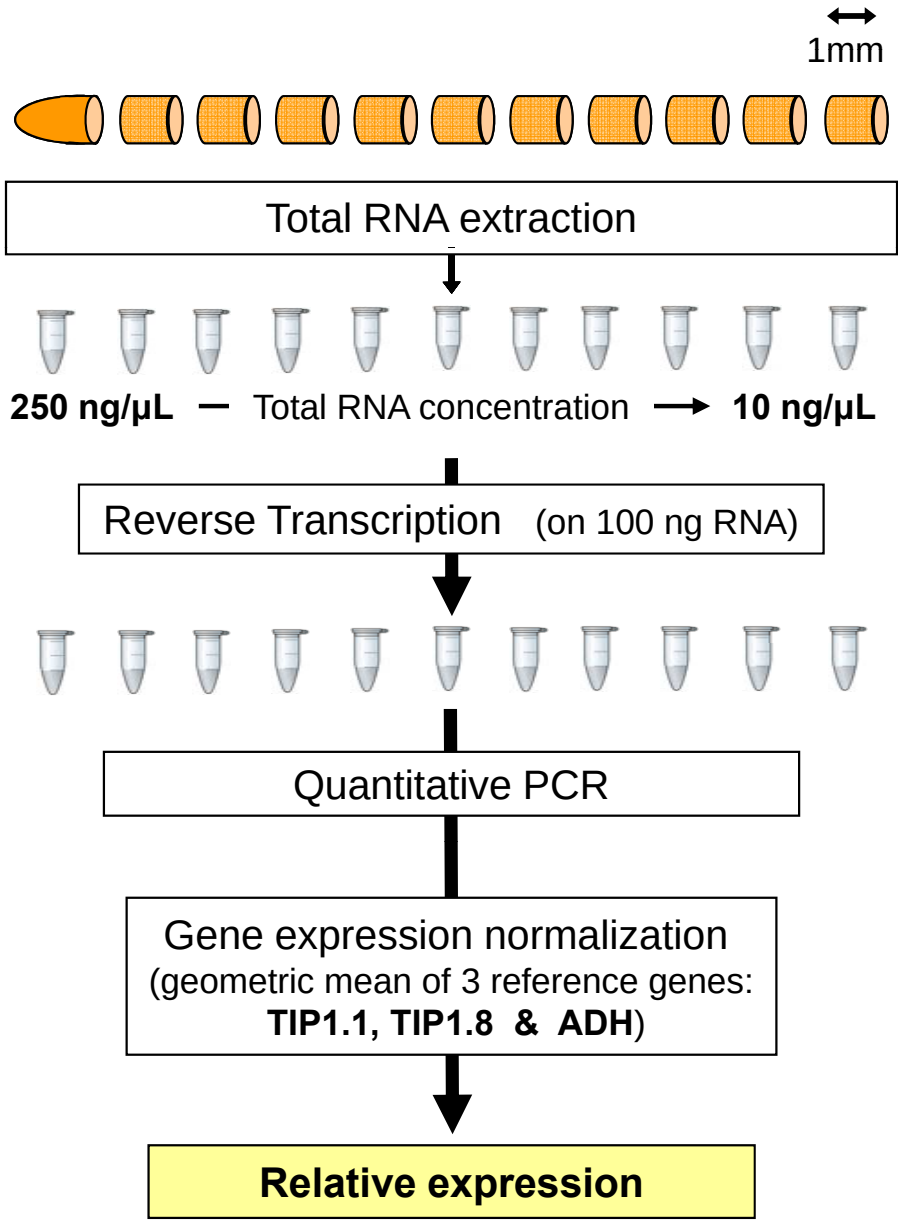
8 *TIP1s* in *Populus trichocarpa* genome
4 paralog pairs (gene duplication)

Our questions

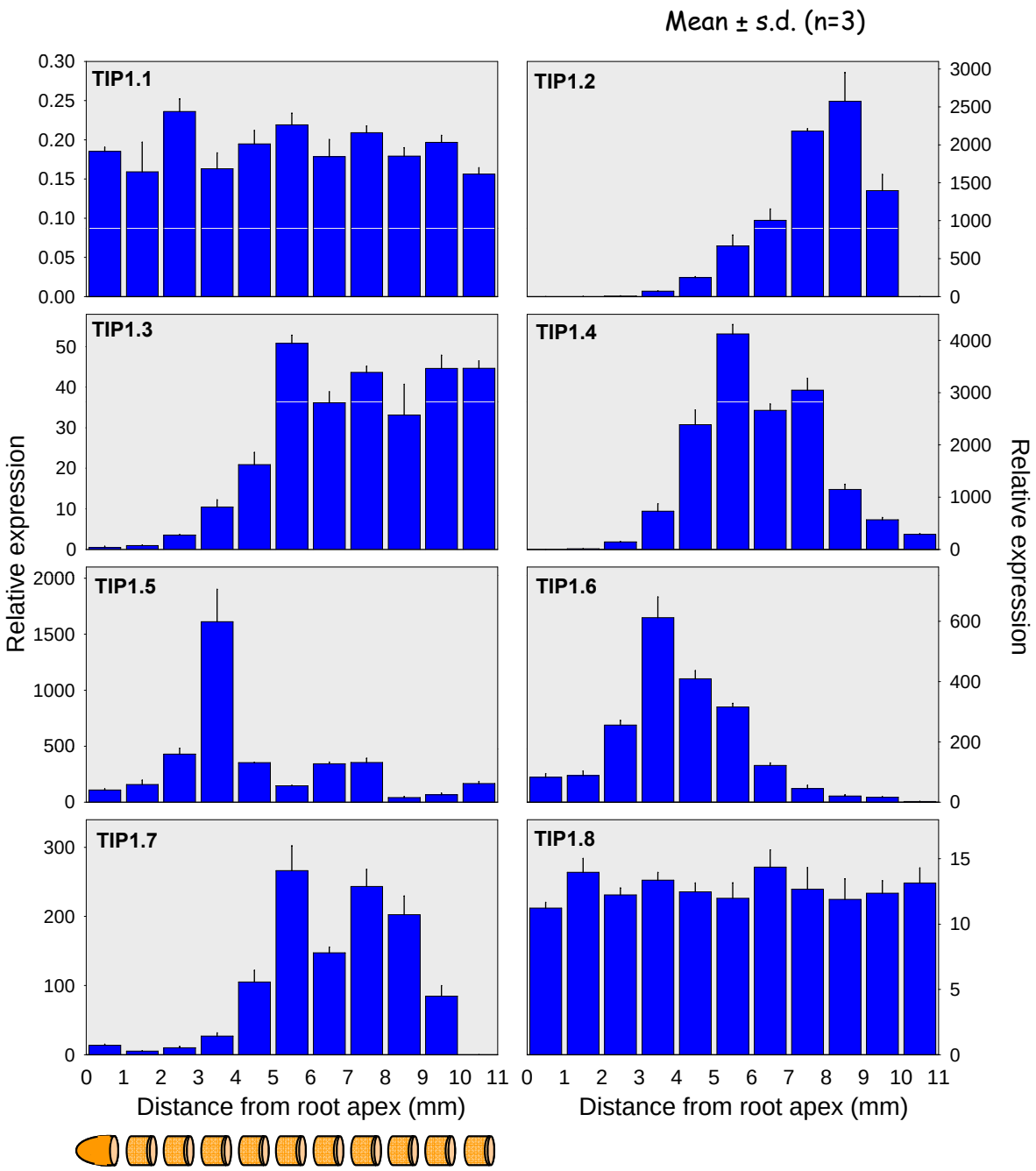
- 1- Expression of *TIP1s* in the growing zone of the poplar root ?
- 2- How is the expression level of *TIP1s* affected by osmotic stress ?
- 3- Can we access to the regulation of *TIP1s* expression ?

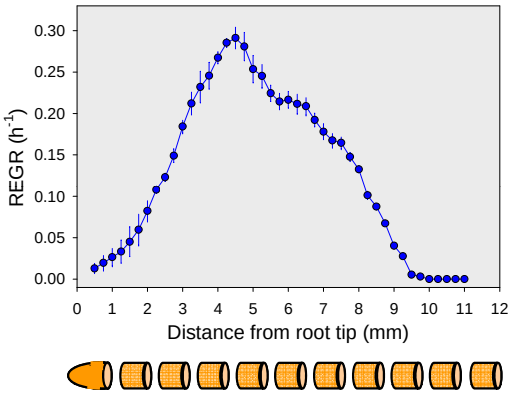
1- Relative expression of TIP1s in the growing zone of the root





1- Relative expression of TIP1s in the growing zone of the root

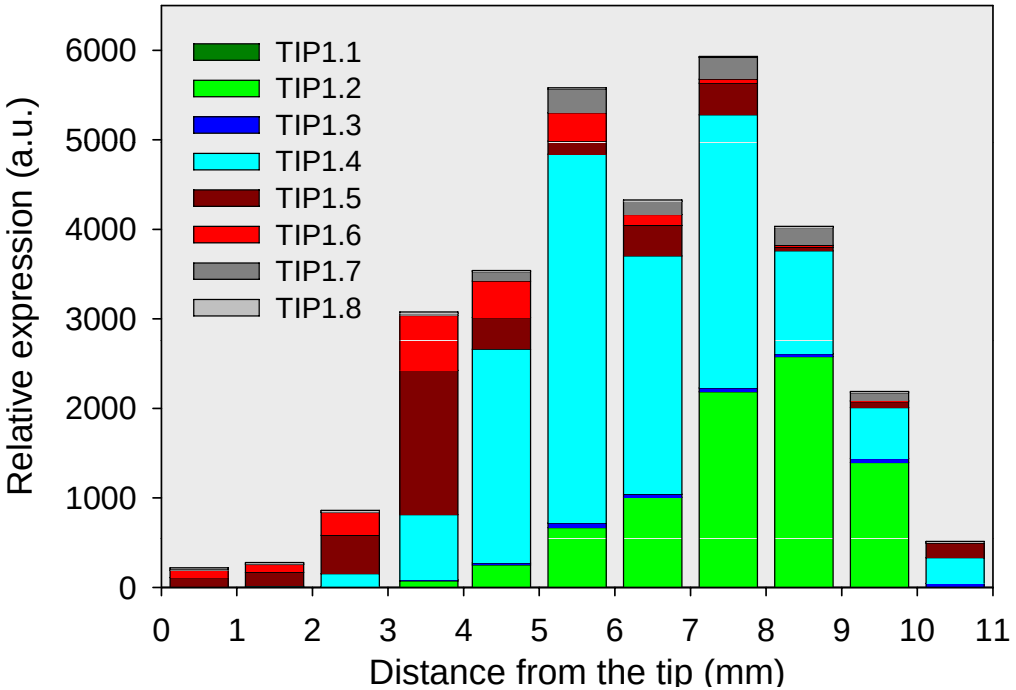


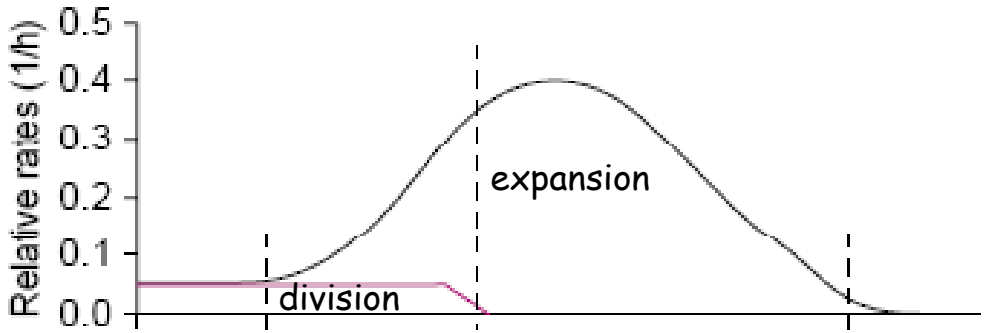


Relative expression along the root growth zone:

- stable for *TIP1.1* et *TIP1.8* , as expected
- highly contrasted pattern for the 6 other *TIP1s*
- differences between paralog pairs
- different levels of expression

1- Relative expression of TIP1s in the growing zone of the root

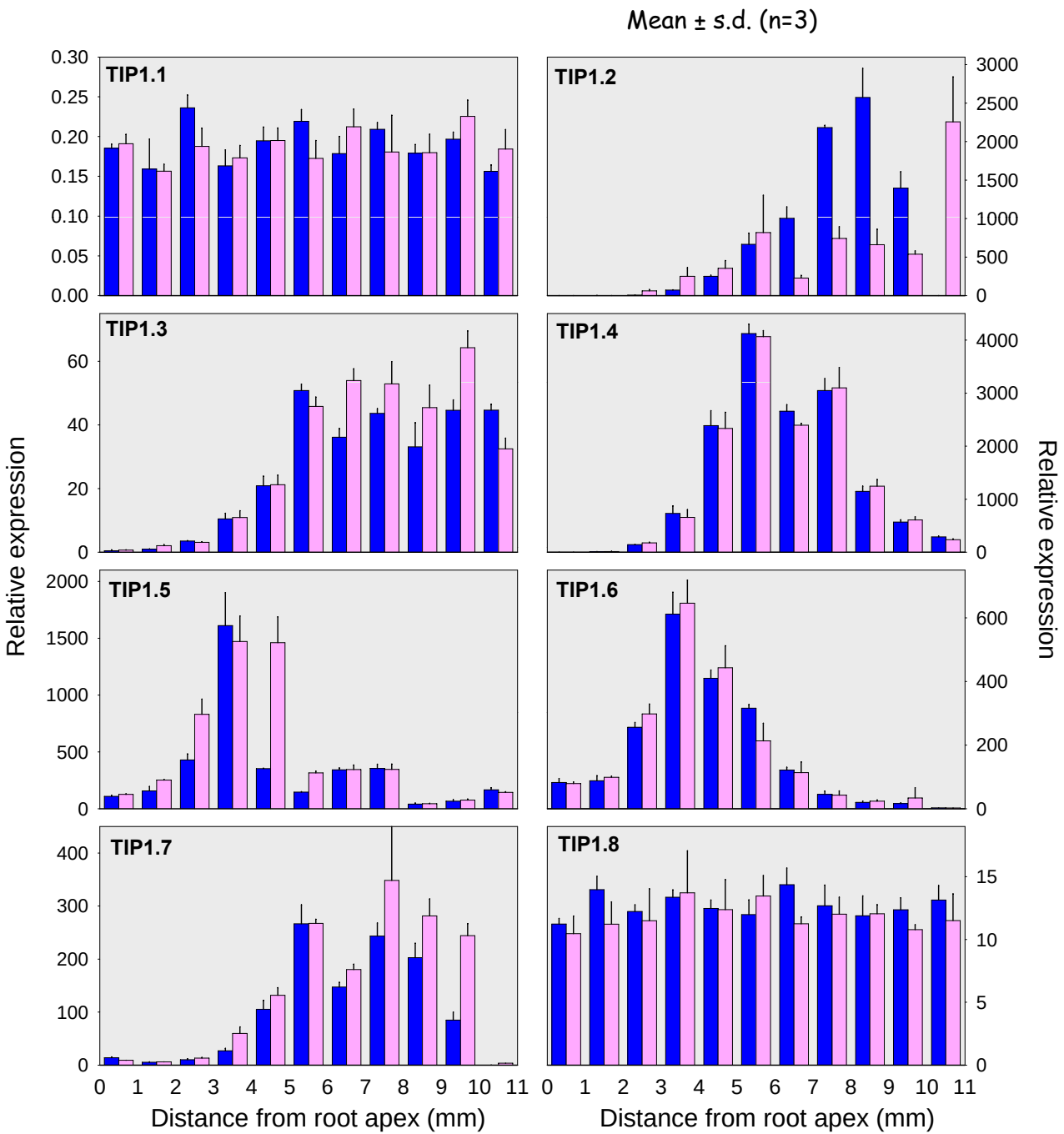




- Level of expression differs between paralogs
- High expression level of *TIP1s* in the growth zone

- Meristem : *TIP1.5* & *TIP1.6*
- Cell expansion : *TIP1.4*
- Distal part : *TIP1.2*

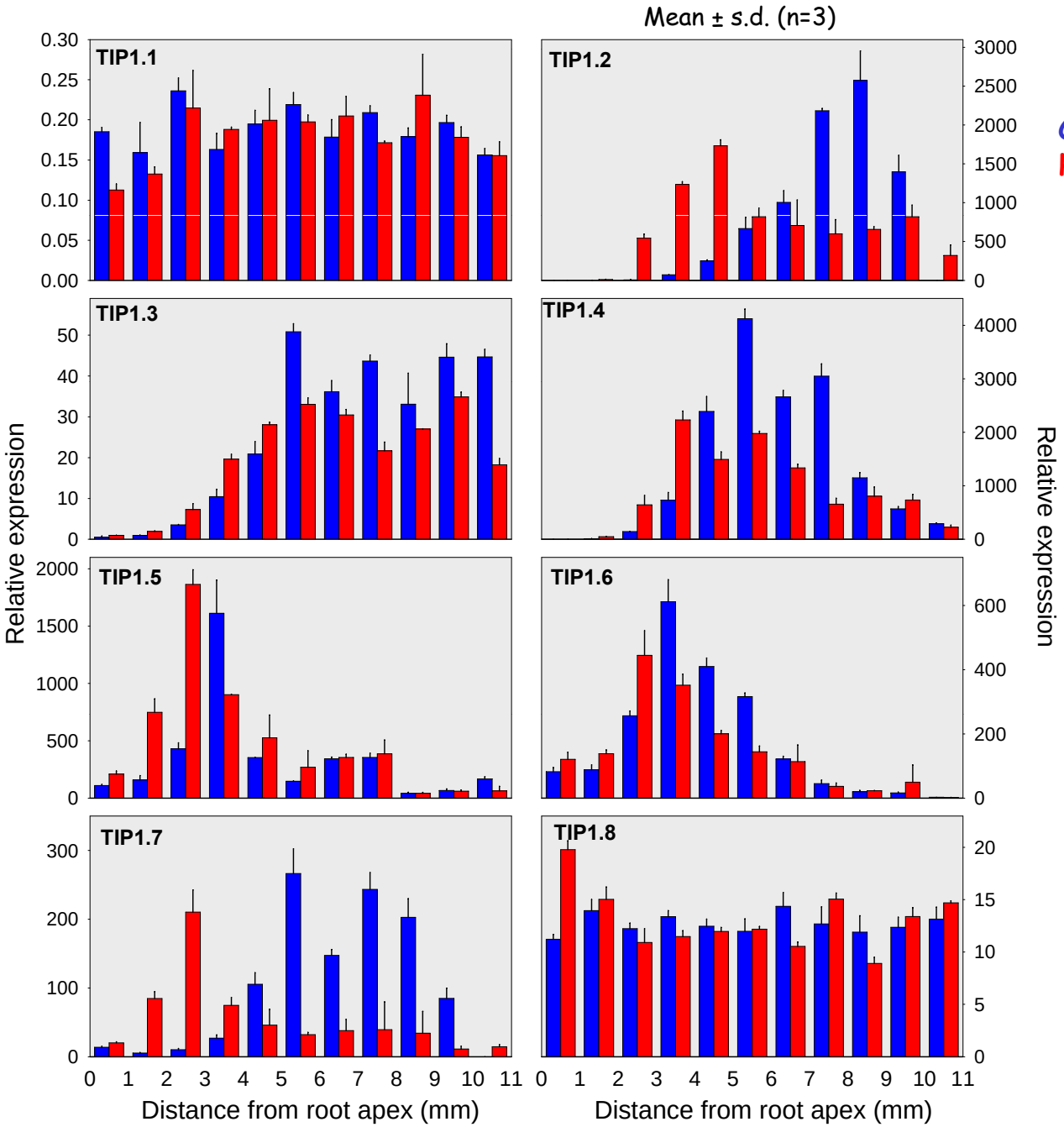
2- Relative expression of TIP1s under moderate osmotic stress



Control
Moderate stress

Low impact of moderate stress

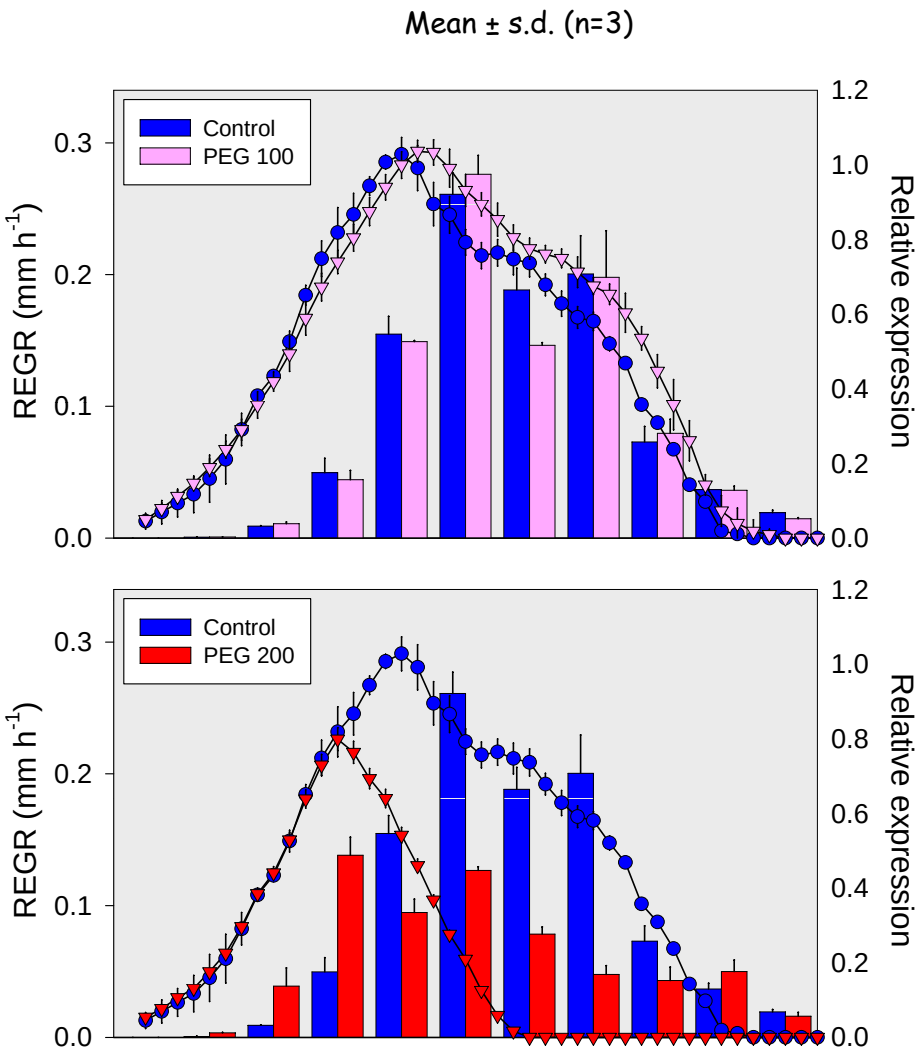
2- Relative expression of TIP1s under high osmotic stress



Effect of high stress:

- similar or lower relative expression
- shift of the maxima towards a more apical position

2- Relative expression of TIP1.4 and cell expansion



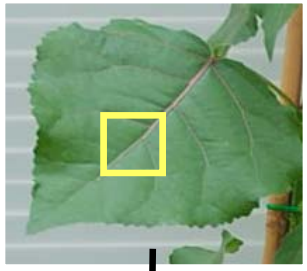
Control
Moderate Stress
High stress

For the 3 growth states :

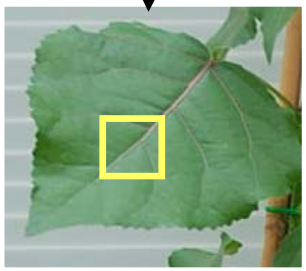
overlapping of REGR pattern and *TIP1.4* expression pattern

-> putative link between TIP1.4 and cell expansion

3- Can we access to the regulation of TIP1s expression ?



t_1



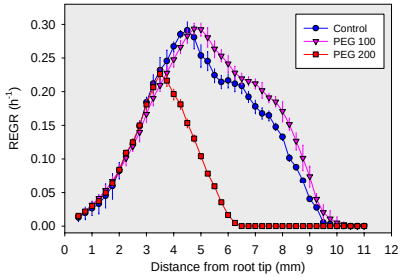
t_2

Mature organ :

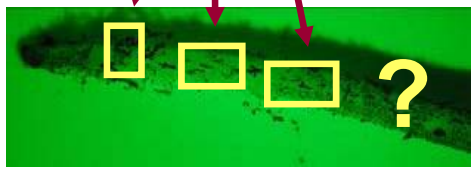
Regulation of gene expression = temporal variation of transcript density

$\delta\rho / \delta t$

t_1



t_2



Growing root

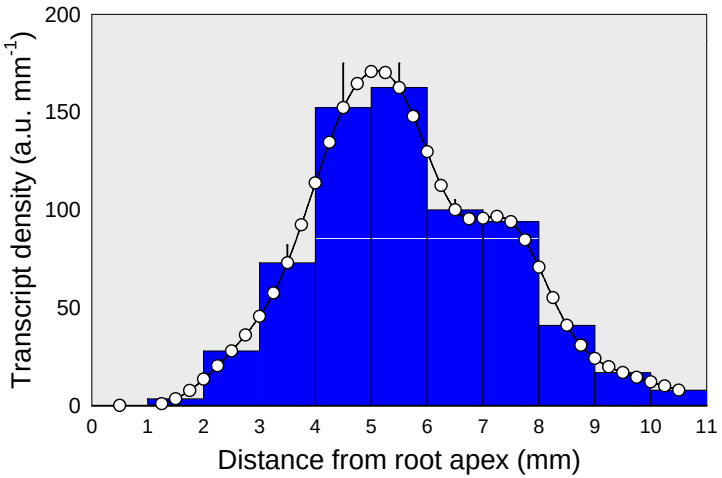
In a **growing organ**, it is necessary to take into account cells movement and their expansion.

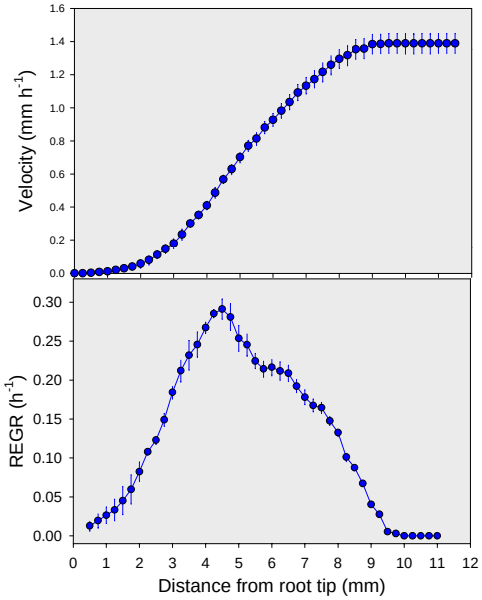
$$D_{(x)} = \underbrace{\frac{\partial \rho}{\partial t}_{(x)}}_{\text{Temporal variation}} + \underbrace{v \frac{\partial \rho}{\partial x}_{(x)}}_{\text{Convection}} + \underbrace{\rho \frac{\partial v}{\partial x}_{(x)}}_{\text{Dilution}}$$

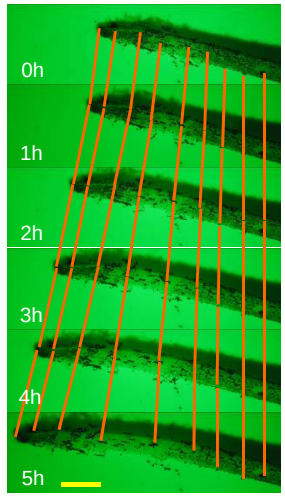
Net accumulation rate

The **continuity equation** (issued from a fluid mechanics formalism) gives access to the **net accumulation rate of transcript**, i.e., the **regulation of gene expression**

3- Spatial pattern of local net transcript accumulation rate

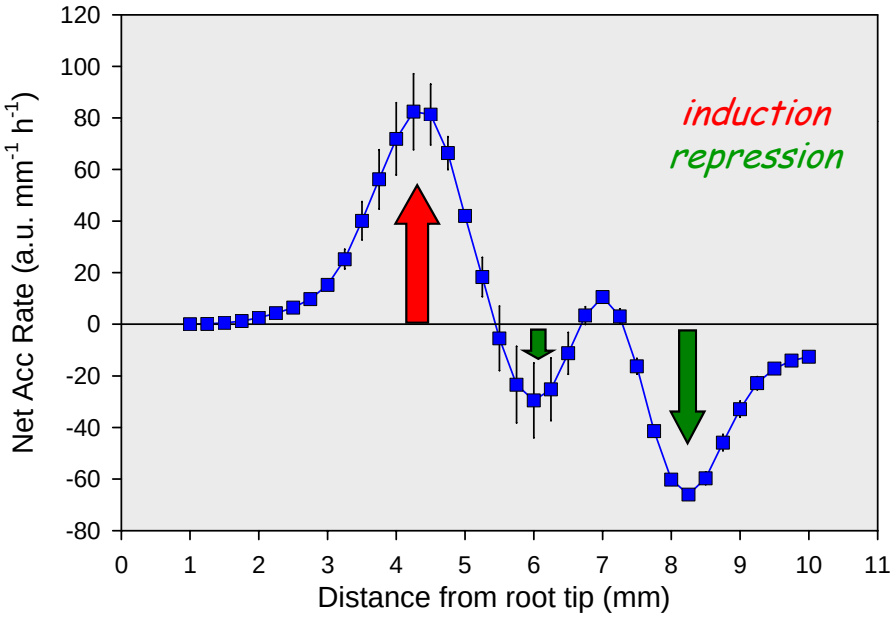






Continuity equation

$$D_{(x)} = \frac{\partial \rho}{\partial t}_{(x)} + v \frac{\partial \rho}{\partial x}_{(x)} + \rho \frac{\partial v}{\partial x}_{(x)}$$

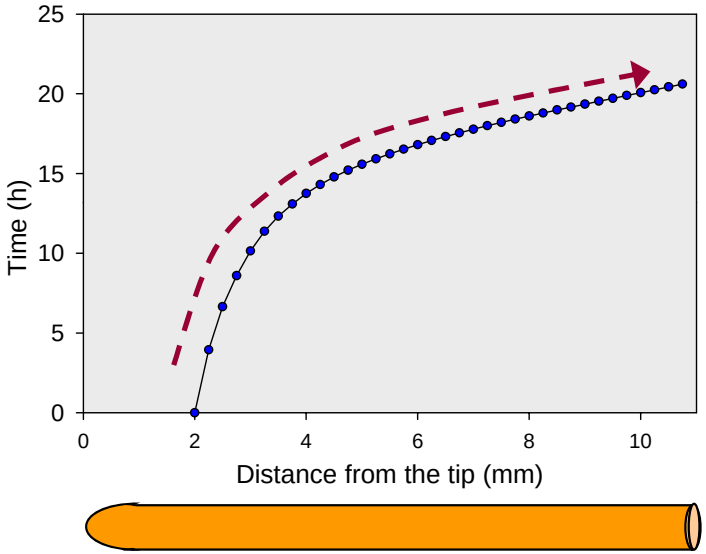


Merret et al. (2010)

3- Spatio-temporal pattern of regulation in a 'moving particule'

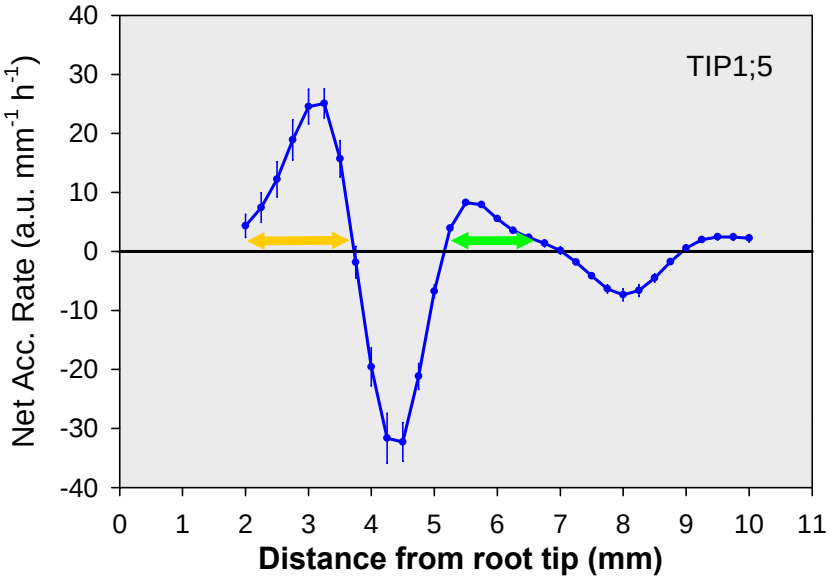
If steady state :

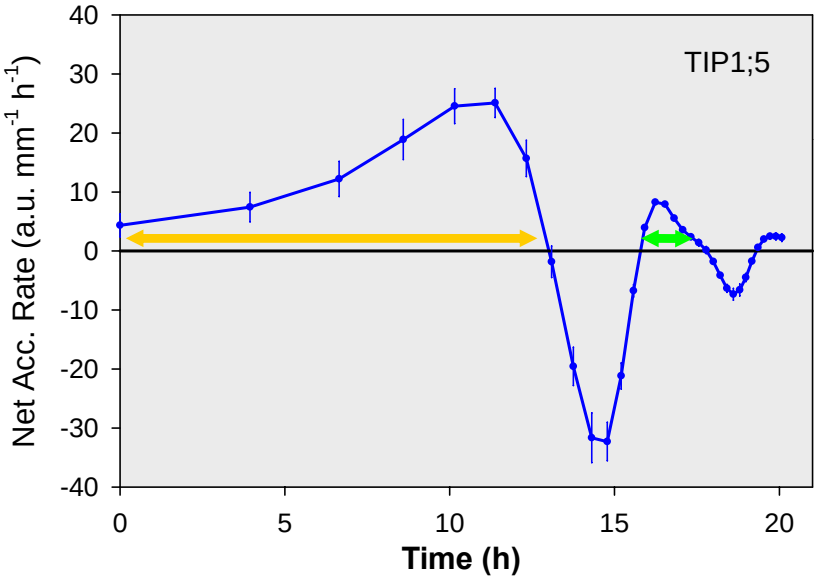
Particule trajectory
time = f (position)



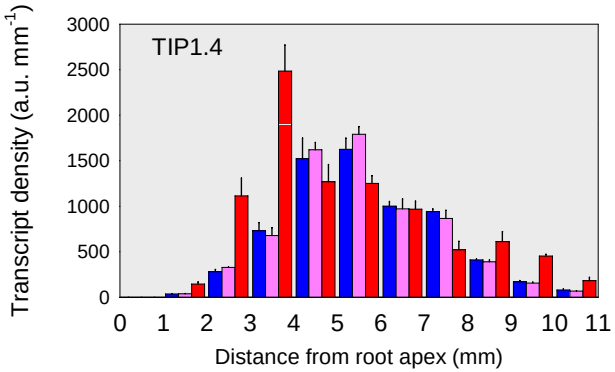
spatial coordinates

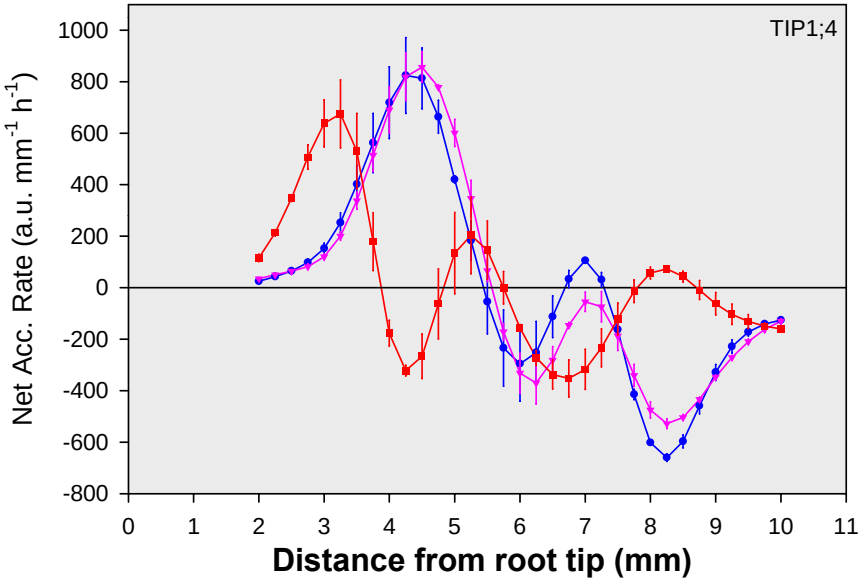
temporal coordinates



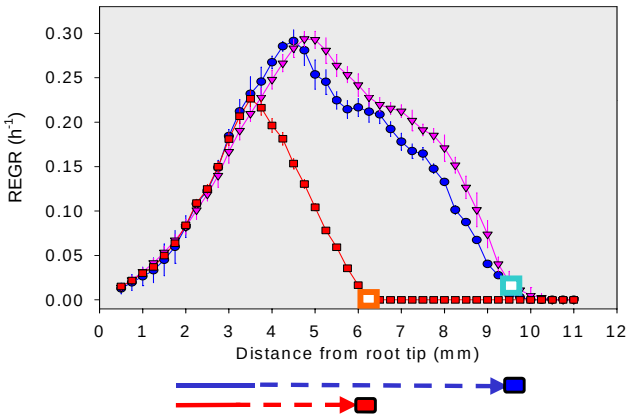


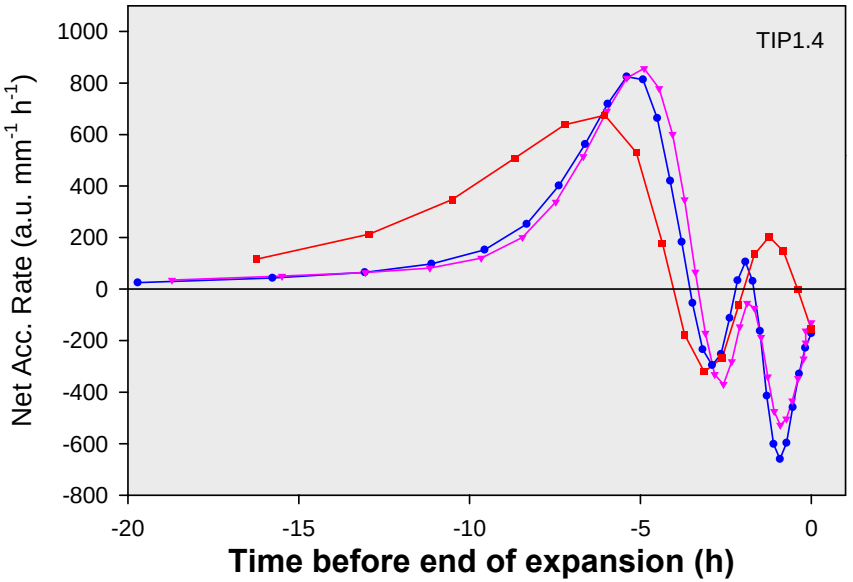
3- Spatio-temporal pattern of TIP1.4 regulation during cell expansion





Saptial regulation of *TIP1.4* expression during cell expansion differs between treatments





Temporal regulation of *TIP1.4* expression during cell expansion very similar in all treatments

-> tight temporal regulation of *TIP1.4* expression

La Région Lorraine

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GENOPLANTE

Project GPLA0628G – 2006/2010

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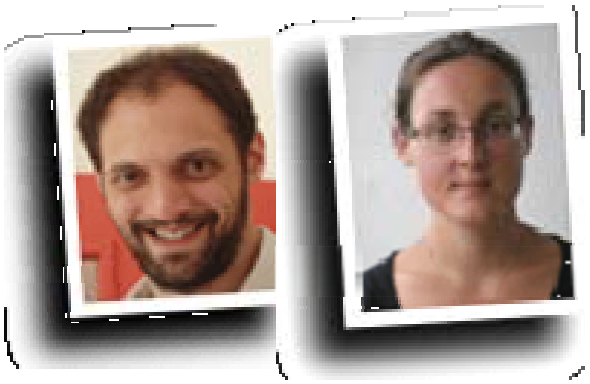

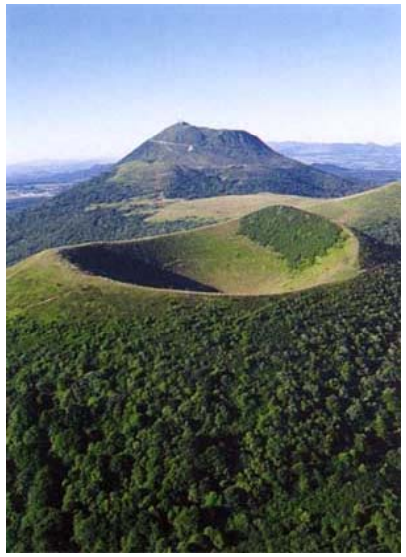

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