



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

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

Nancy-Université
l'Université
Henri Poincaré

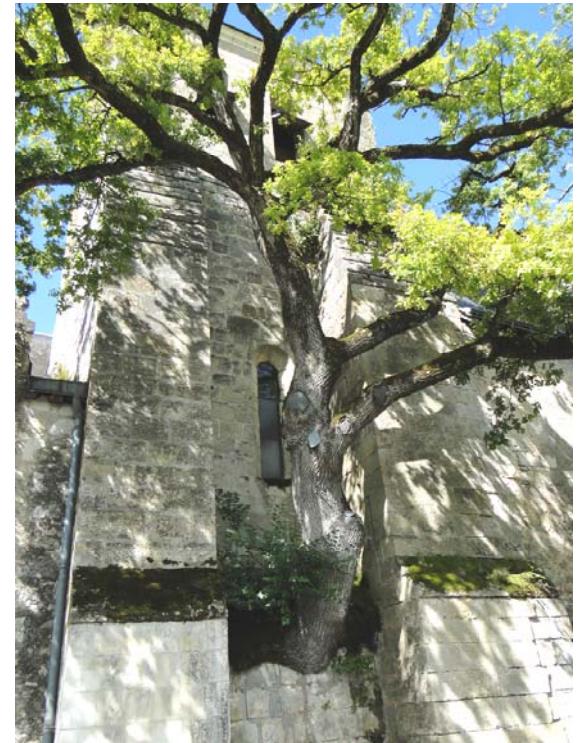
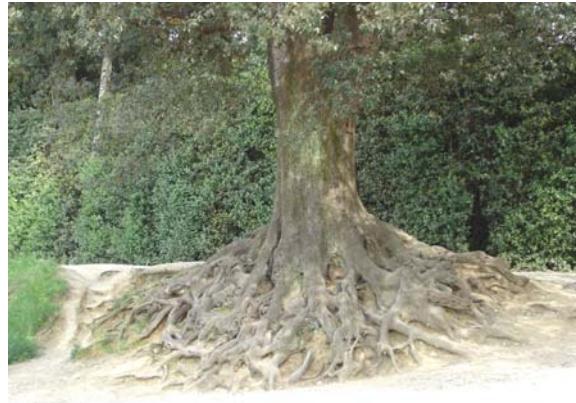


Université Blaise Pascal



Roots

- anchor plants
- uptake water and nutrients



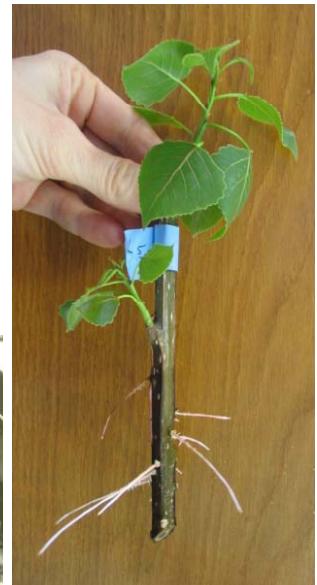
Under drought, growth of roots

- 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 deltoides x nigra cv Soligo
Cuttings grown in hydroponics



Root growth under osmotic stress

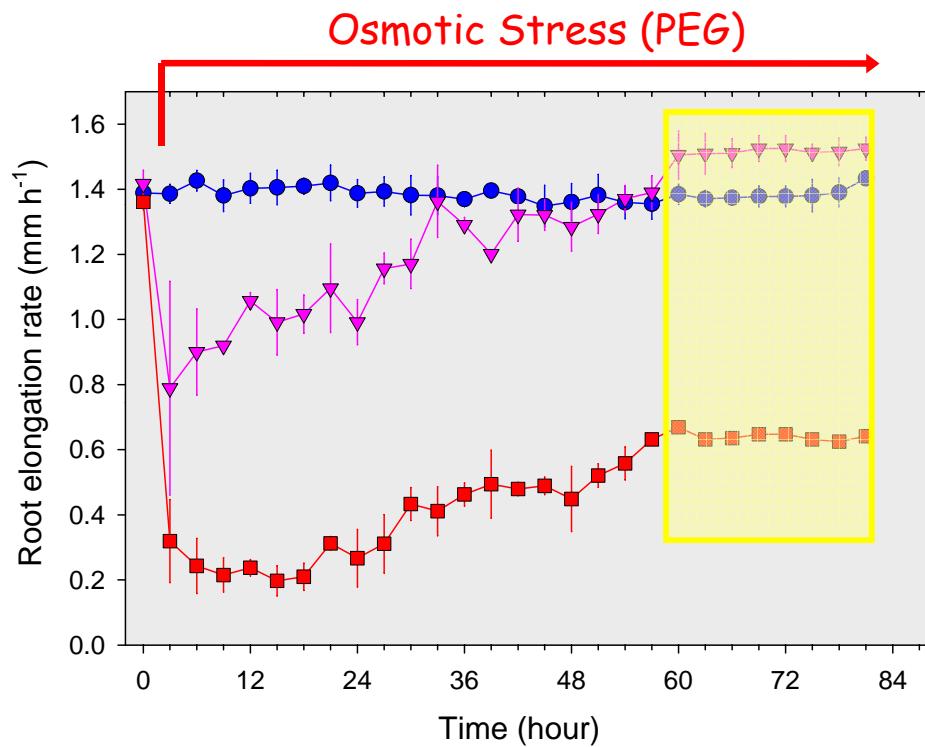
21°C, continuous dark

- Control

2 levels of continuous and stable
osmotic stress (PEG 3350 g mol⁻¹) :

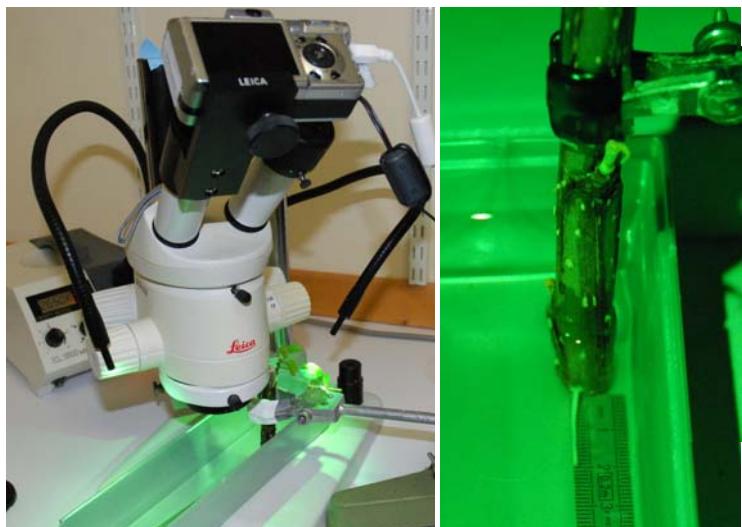
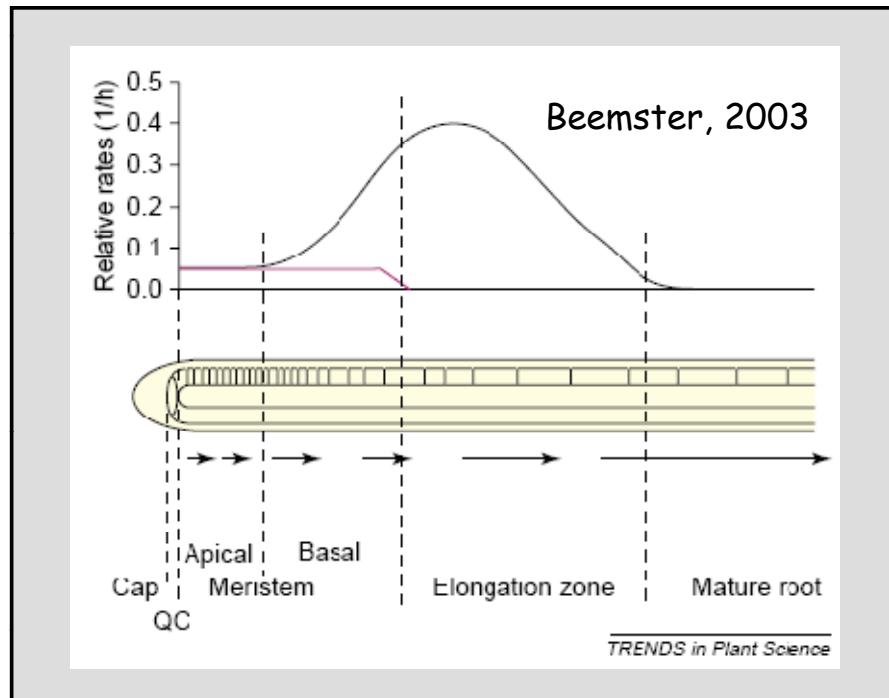
- Moderate stress :
(90 mosmol kg⁻¹, 100g L⁻¹ PEG)

- High stress :
(260 mosmol kg⁻¹, 200g L⁻¹ PEG)

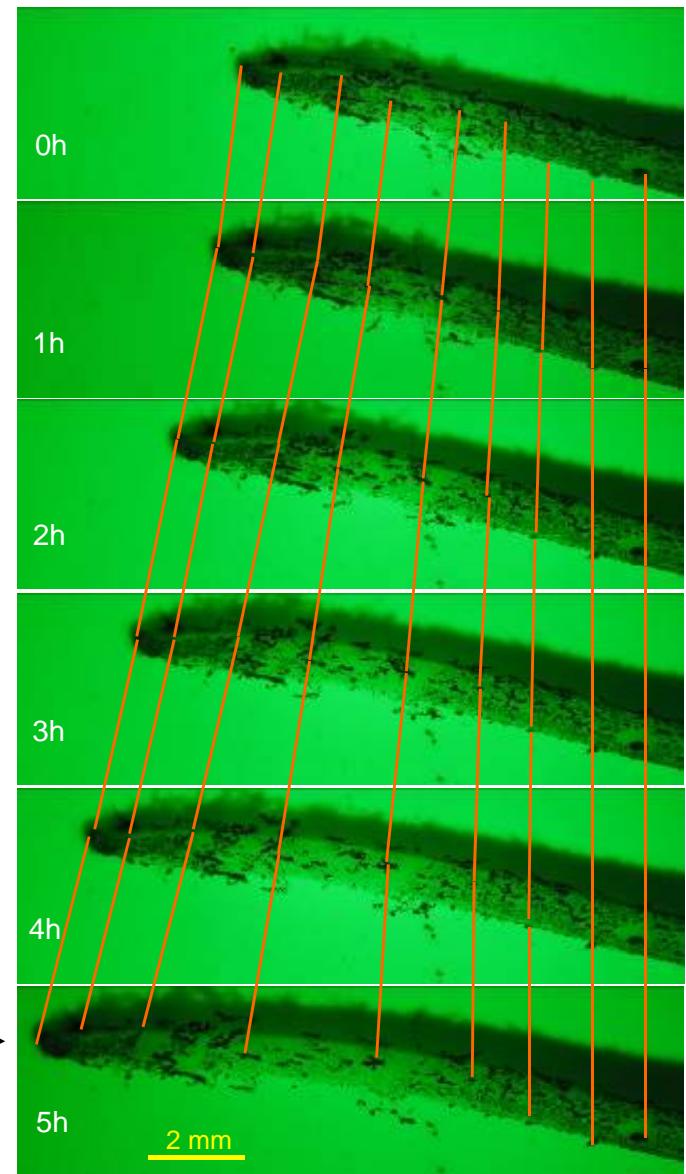


- steady state
- 3 contrasted elongation rates
 - control
 - moderate stress : slightly higher than control
 - high stress : lower than control

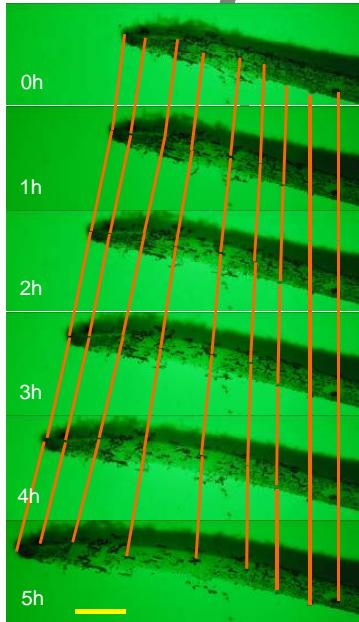
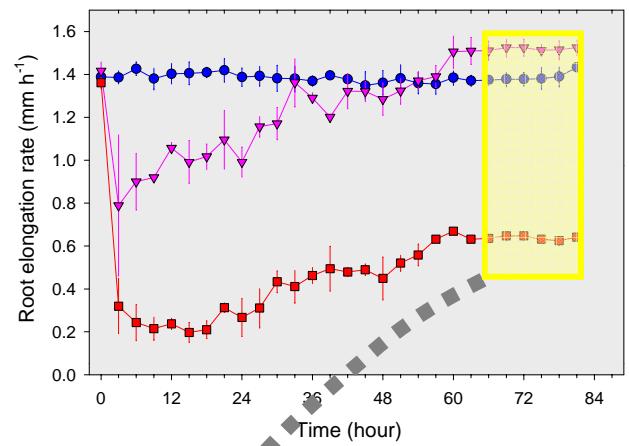
Root elongation results from cell division and cell expansion



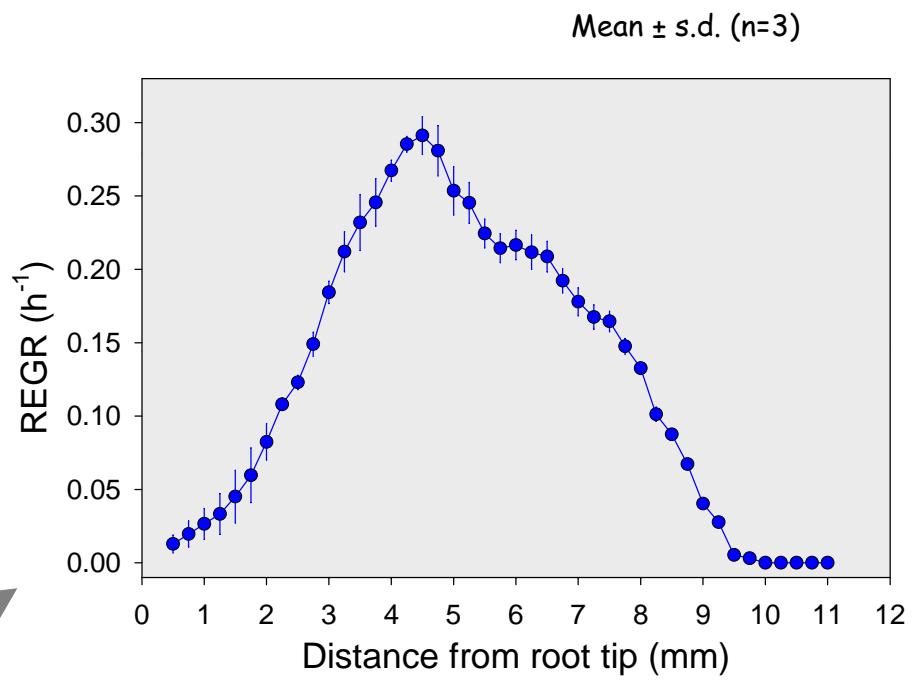
Carbon
particles
deposition
&
in vivo
time laps
photography



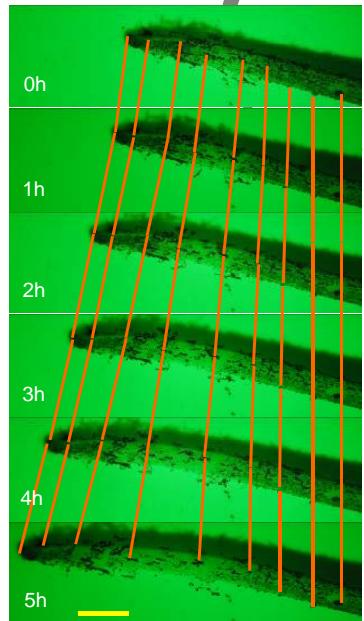
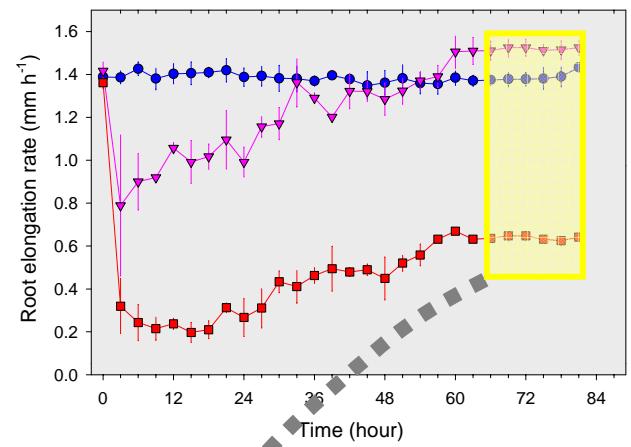
Relative Elemental Growth Rate



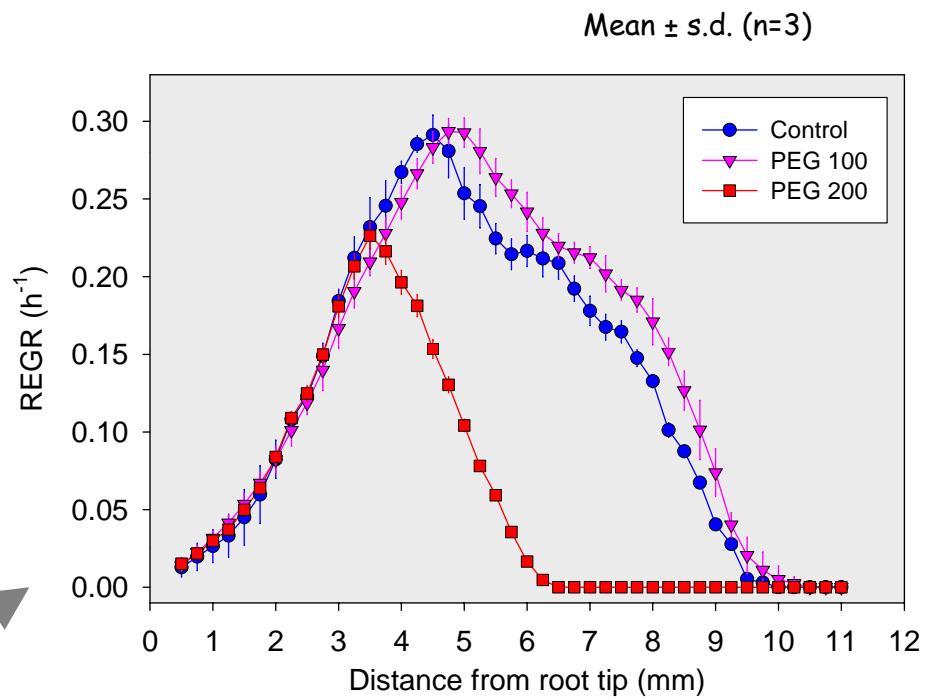
kinematic analysis
Kineroott
(Basu et al, 2007)



Relative Elemental Growth Rate



kinematic analysis
Kineroot
(Basu et al, 2007)

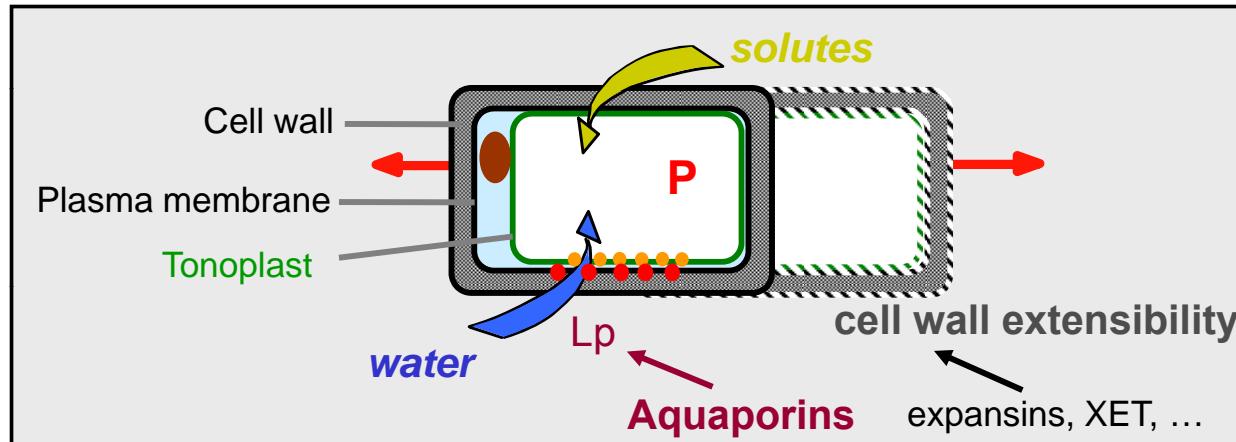


- REGR differentially affected along the growth zone
- Cell expansion rate differentially affected

Are growth alterations due to variations of hydraulic conductivity ?

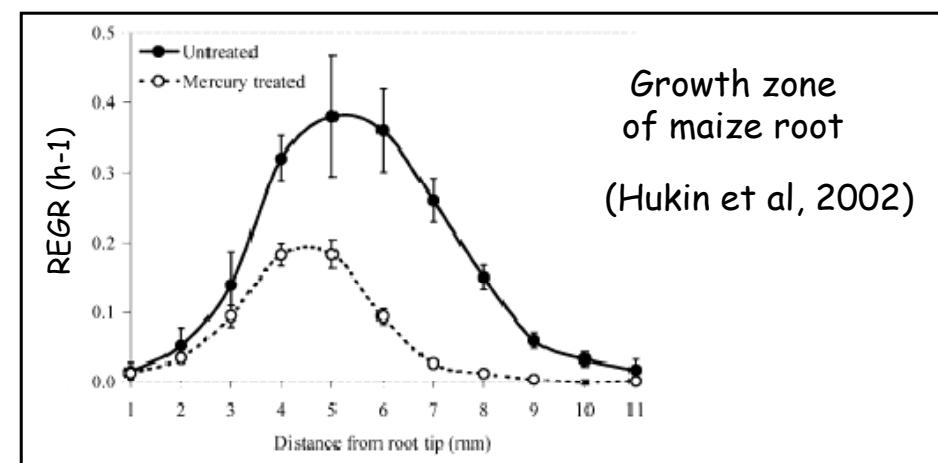
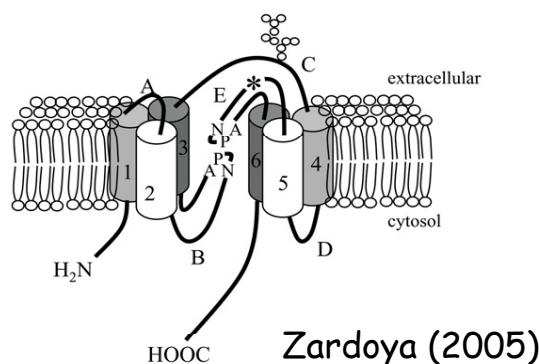
Biophysical model of cell expansion (Lockhart, 1965) :

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



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

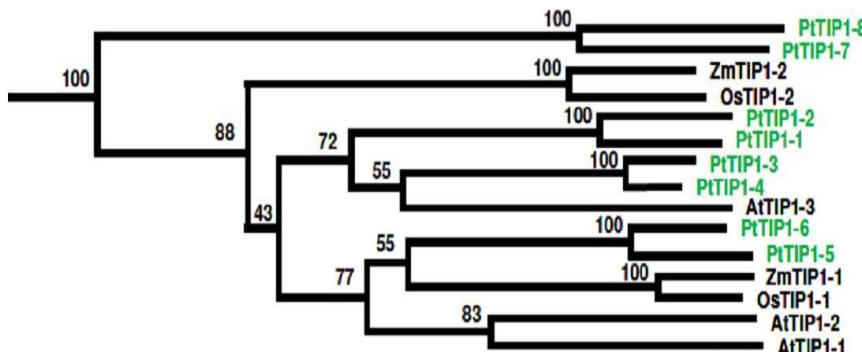
↳ Involvement of aquaporins ?



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*

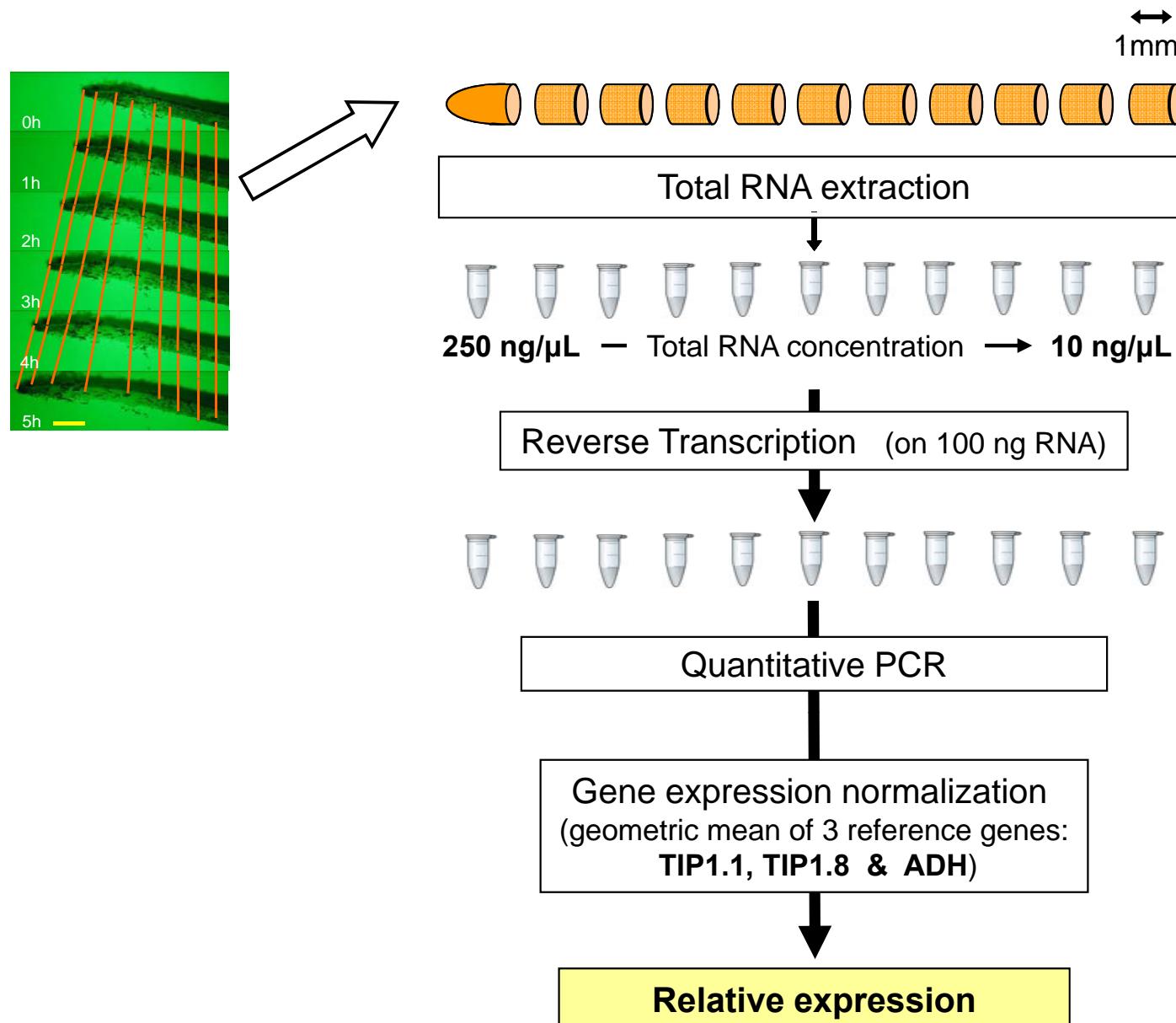


8 *TIP1s* in *Populus trichocarpa* genome
4 paralog pairs (gene duplication)

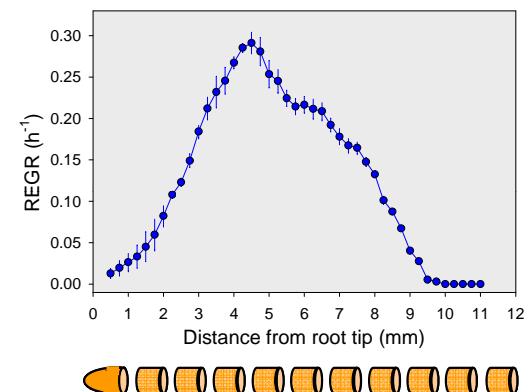
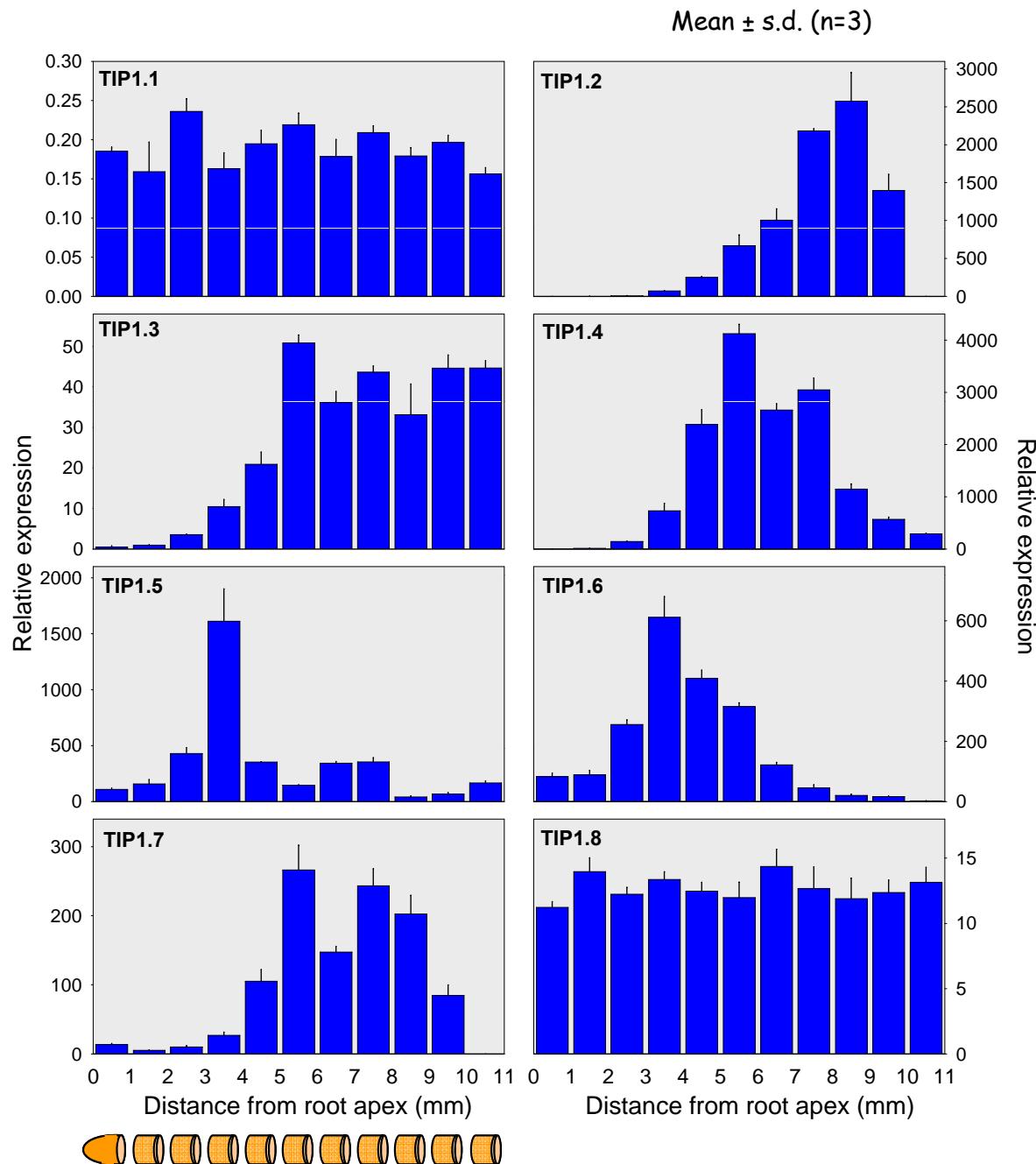
Our questions

- ↳ 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



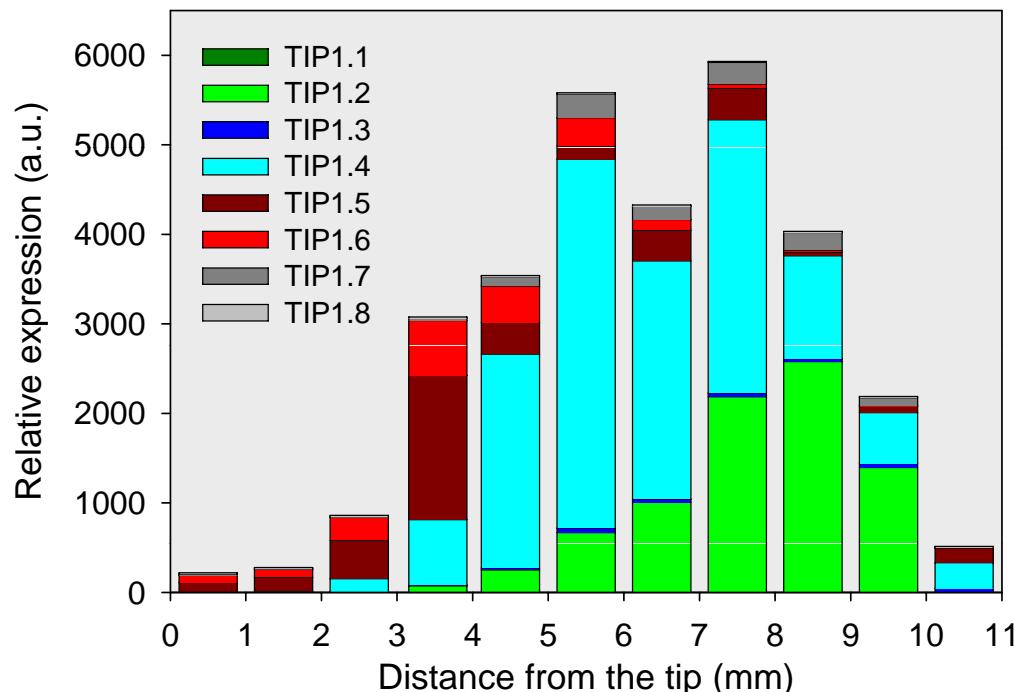
1- Relative expression of *TIP1s* in the growing zone of the root



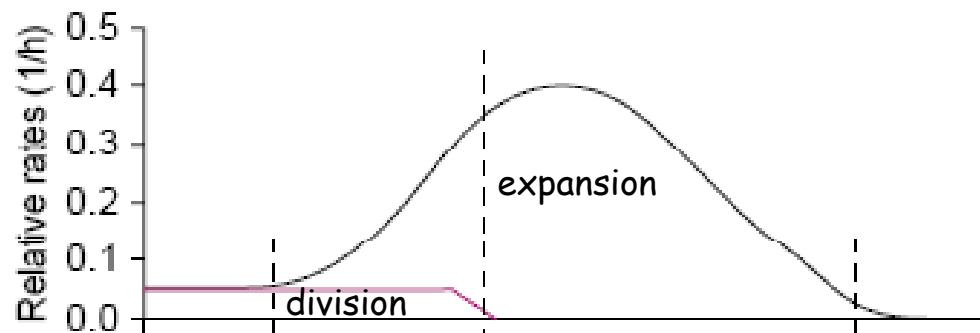
Relative expression along the root growth zone:

- 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

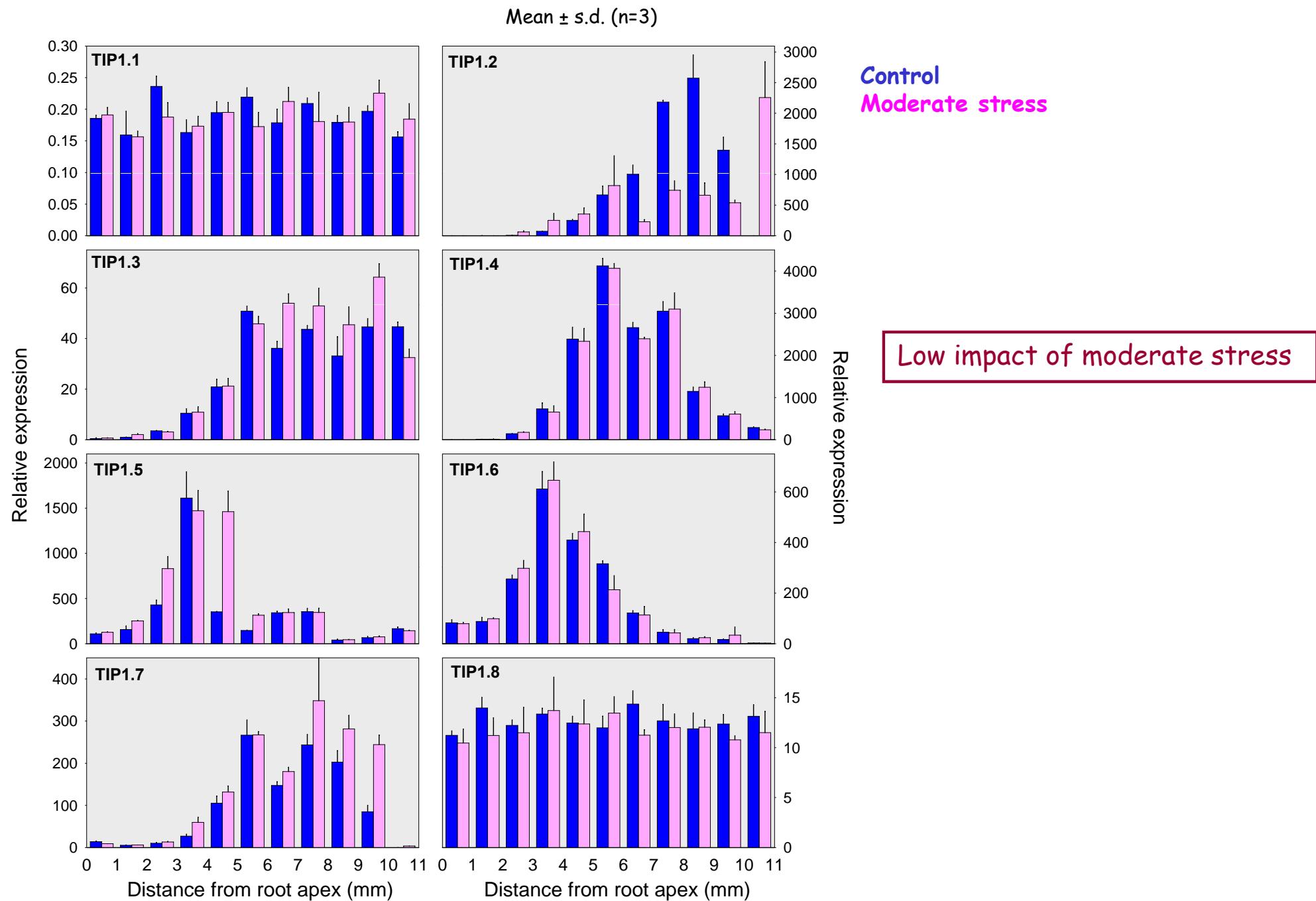
1- Relative expression of *TIP1s* in the growing zone of the root



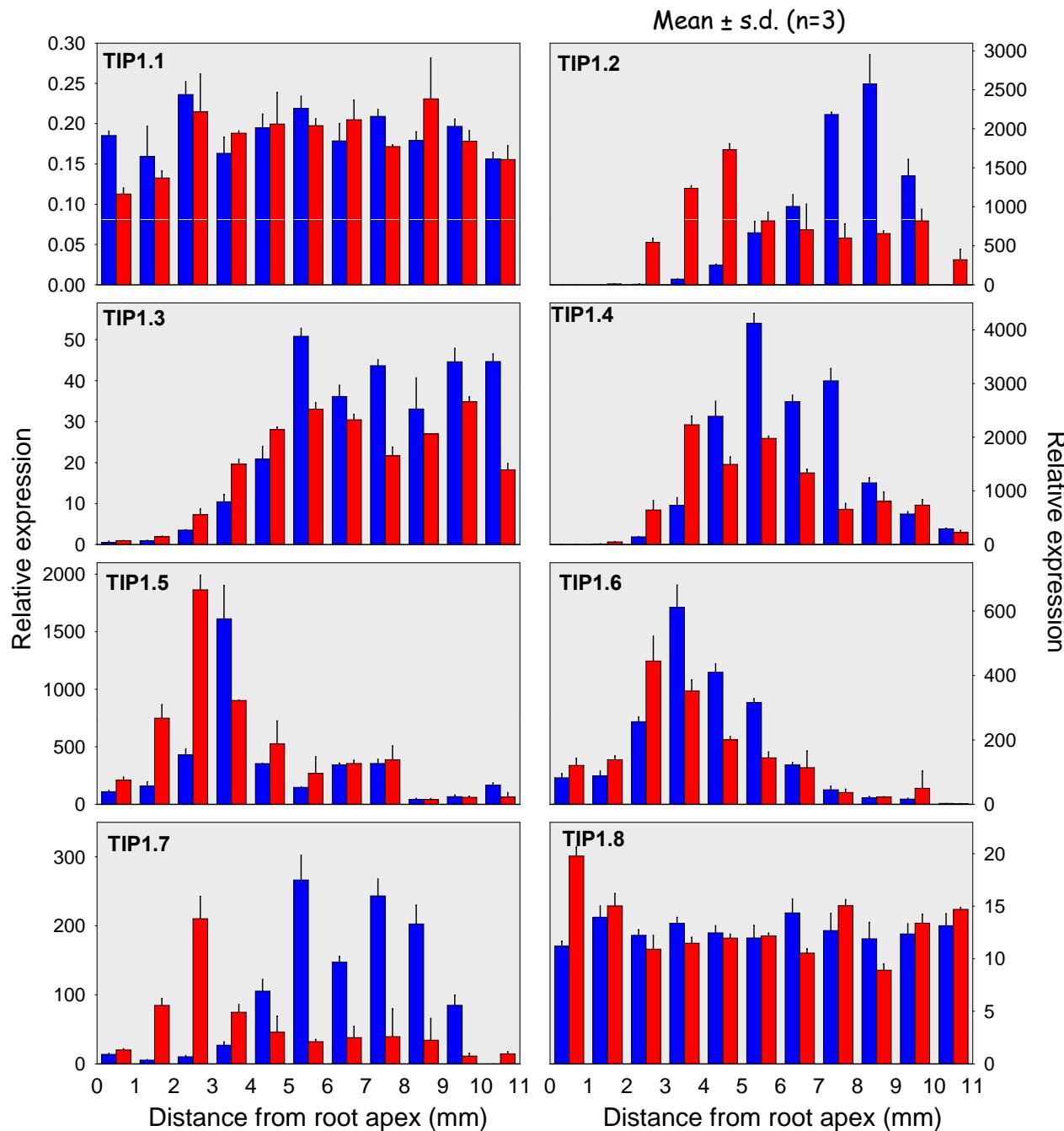
- Level of expression differs between paralogs
- High expression level of *TIP1s* in the growth zone
- Meristem : *TIP1.5 & TIP1.6*
- Cell expansion : *TIP1.4*
- Distal part : *TIP1.2*



2- Relative expression of TIP1s under moderate osmotic stress



2- Relative expression of TIP1s under high osmotic stress

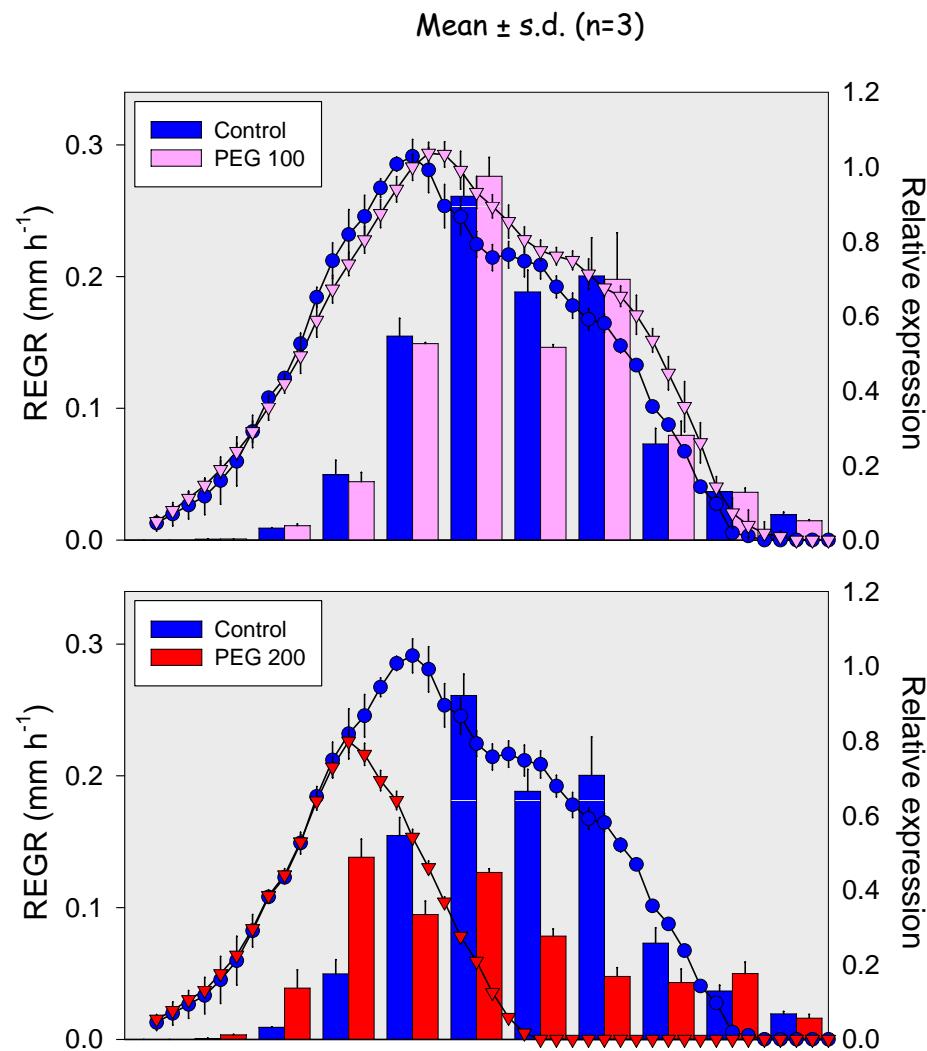


Control
High stress

Effect of high stress:

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

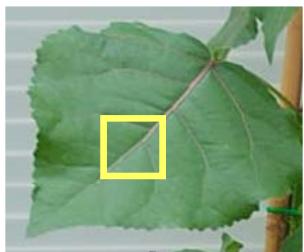
2- Relative expression of *TIP1.4* and cell expansion



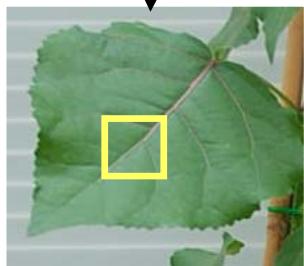
Control
Moderate Stress
High stress

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

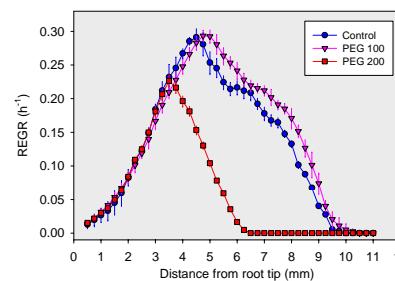
Mature organ :

Regulation of gene expression = temporal variation of transcript density

$$\frac{\delta \rho}{\delta t}$$



t_1



Growing root



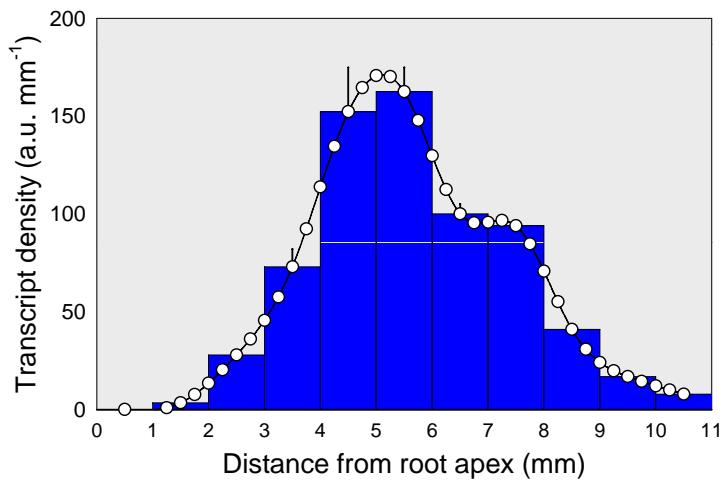
t_2

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

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

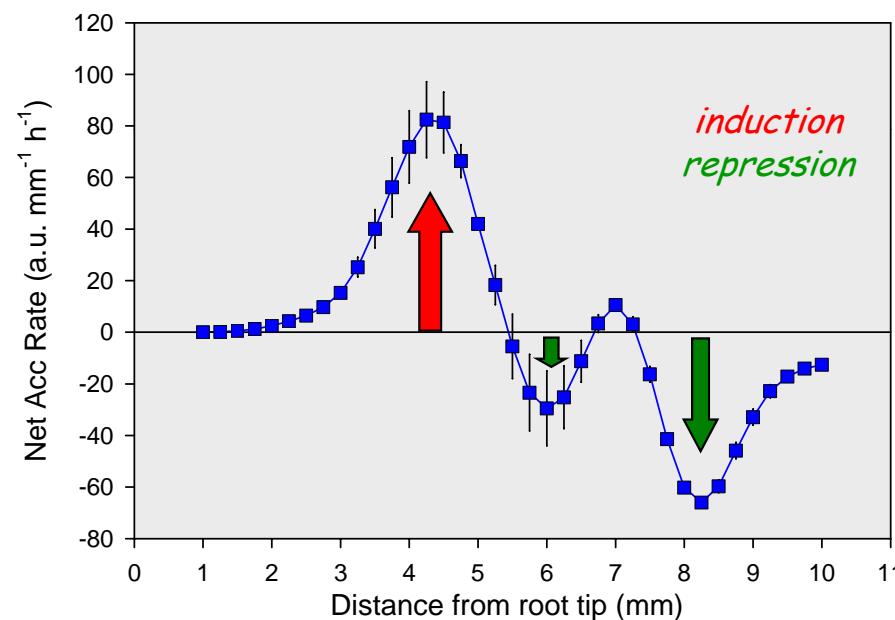
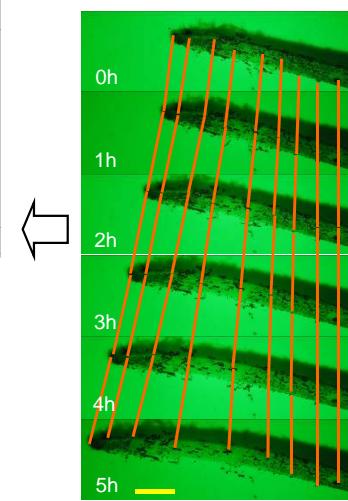
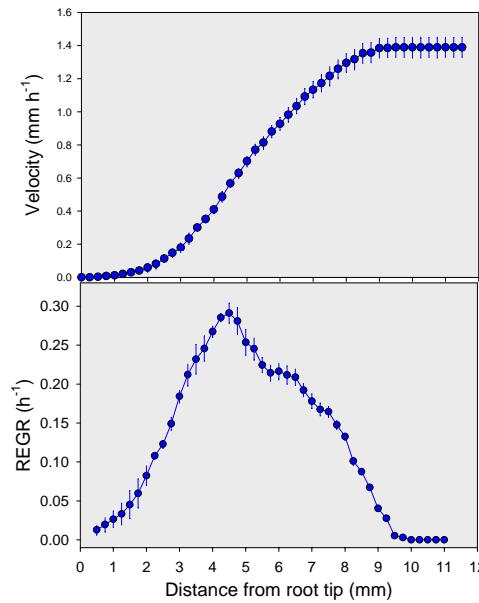
The continuity equation (issued from a fluid mechanics formalism) gives access to the net accumulation rate of transcript, i.e., the regulation of gene expression

3- Spatial pattern of local net transcript accumulation rate



Continuity equation

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

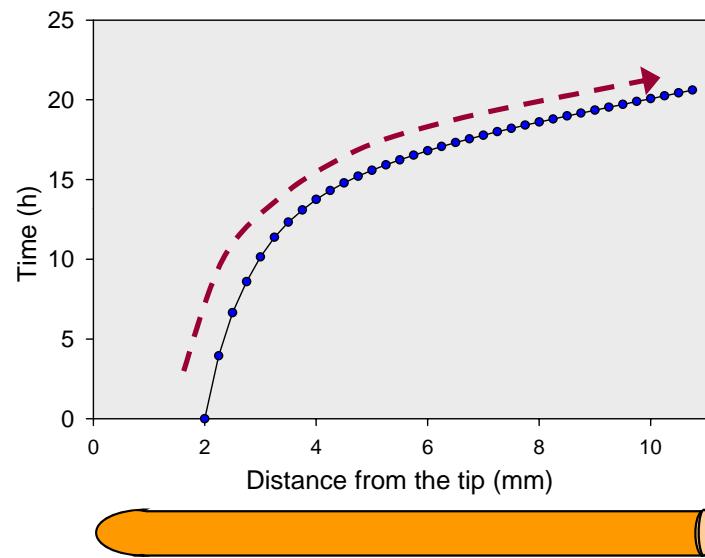


Merret et al. (2010)

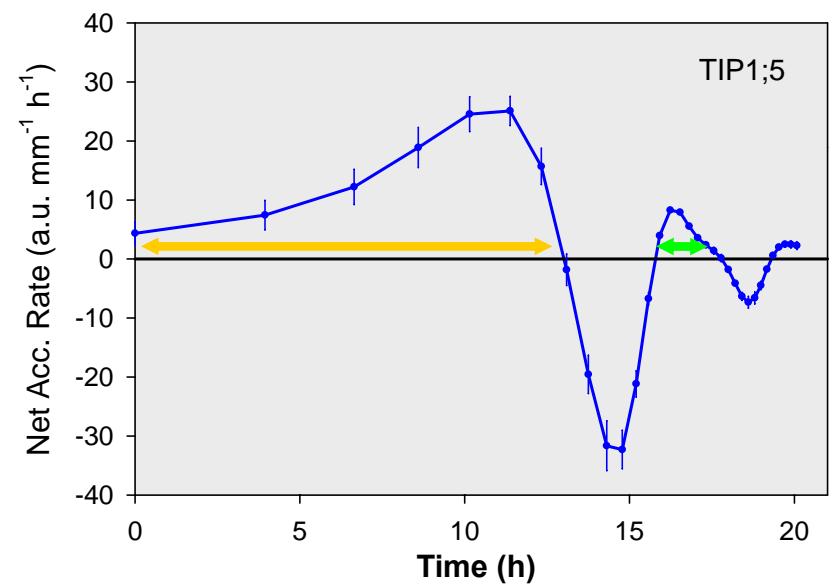
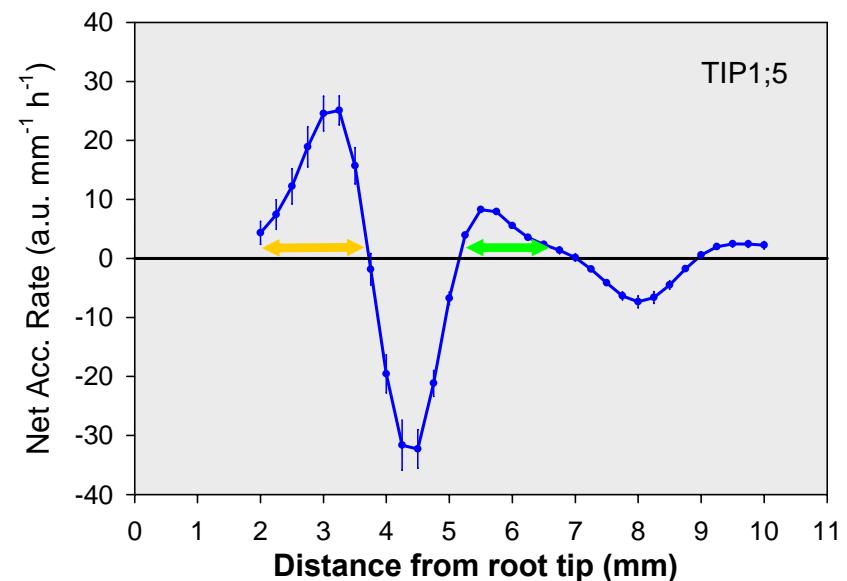
3- Spatio-temporal pattern of regulation in a 'moving particule'

If steady state :

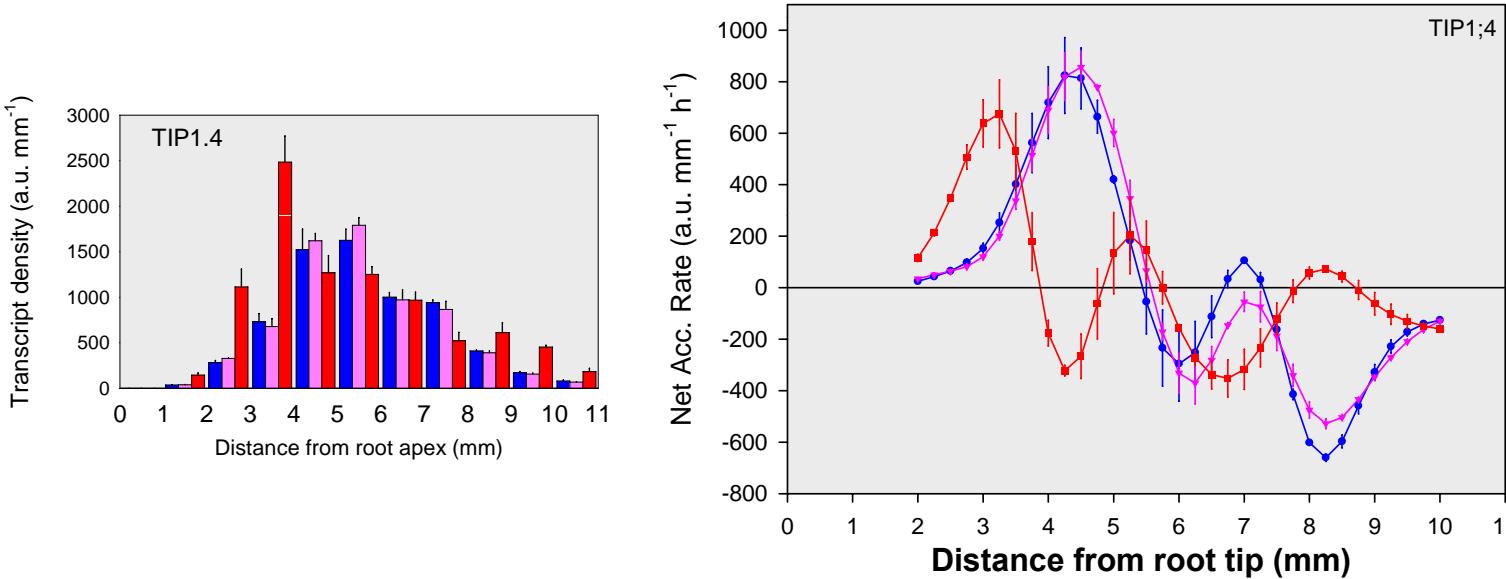
Particule trajectory
time = f (position)



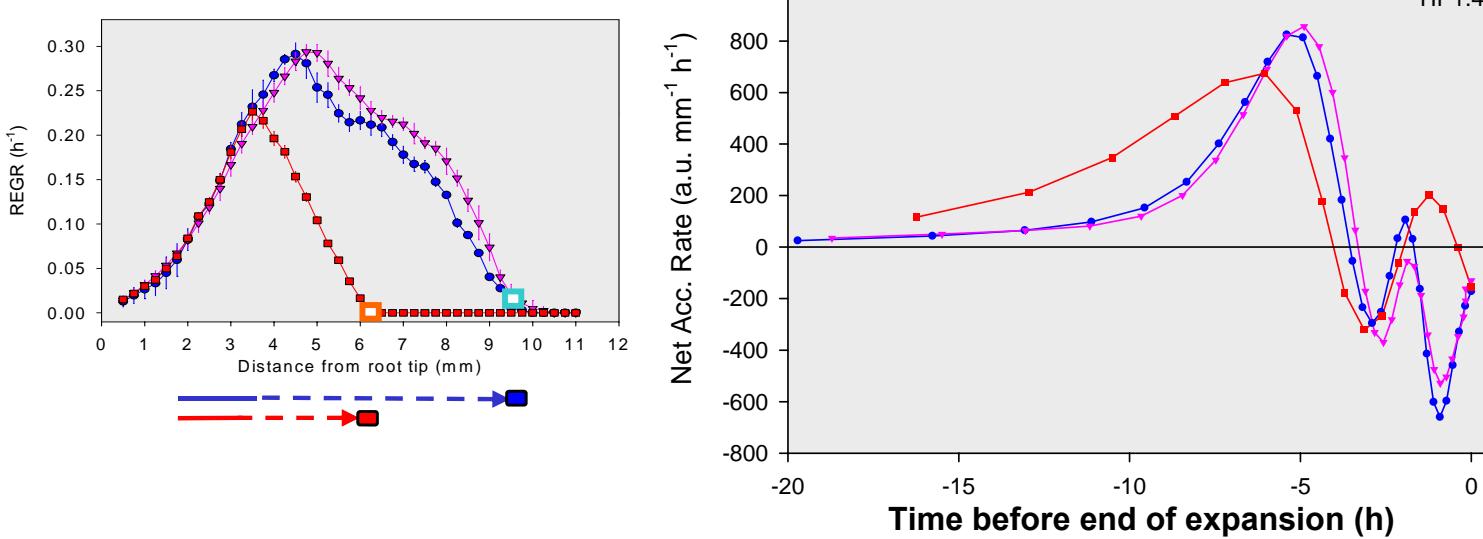
spatial coordinates
↓
temporal coordinates



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



Spatial 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



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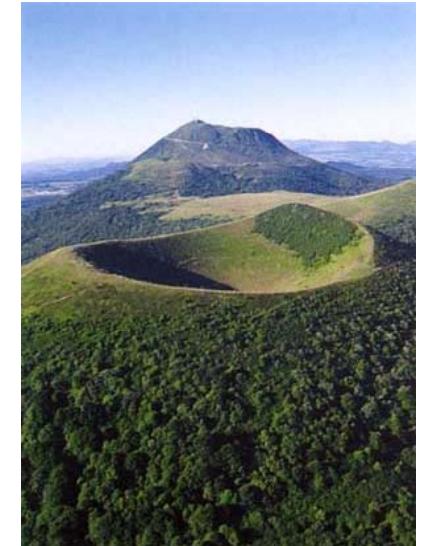
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Thanks for your attention