Acclimation of Populus to wind: kinetic of the transcriptomic response to single or repeated stem bending

Lise Pomies, Mélanie M. Decourteix, Jérôme J. Franchel, Bruno B. Moulia, Nathalie Leblanc-Fournier

Acclimation of *Populus* to wind: kinetic of the transcriptomic response to single or repeated stem bending.

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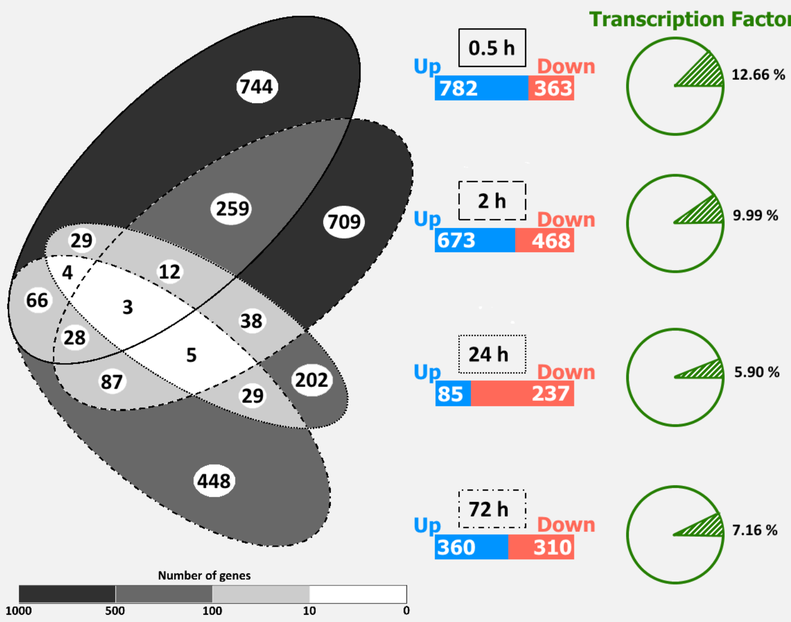
Storms are the 1st cause of damages to European forests. Trees are sensitive to stem bending due to chronic wind. After 1 bending, they respond by modifying their growth during several days [1]. However, repeated stem bending induce a reduction in tree responsiveness, a phenomenon called accommodation [2][3]. Due to climate changes, strong wind may be more frequent [4]. ***How will trees acclimate or not to such new wind regimes?***

First global and kinetic picture of molecular responses to stem bending

Long-term time series expression profiling



Gene expression modifications were assessed at 0.5 h, 2 h, 24 h and 72 h after a **transitory controlled bending** (with *Affymetrix* microarray).

→ **2,633 differentially expressed genes** (DEG)

→ 75.6% of DEG are detected at 0.5 h and 2 h after the bending

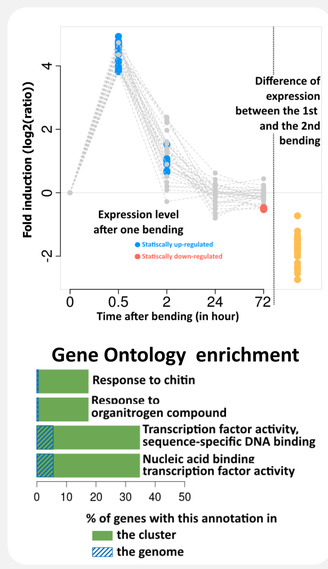
→ Many DEG are **detected at several time points.**

Identification & characterization of temporal patterns in gene expression

k-means clustering
⇨**40** different **temporal patterns** (clusters)

Gene Ontology (GO) **enrichment** in each cluster
⇨Temporal patterns are assigned a biological function

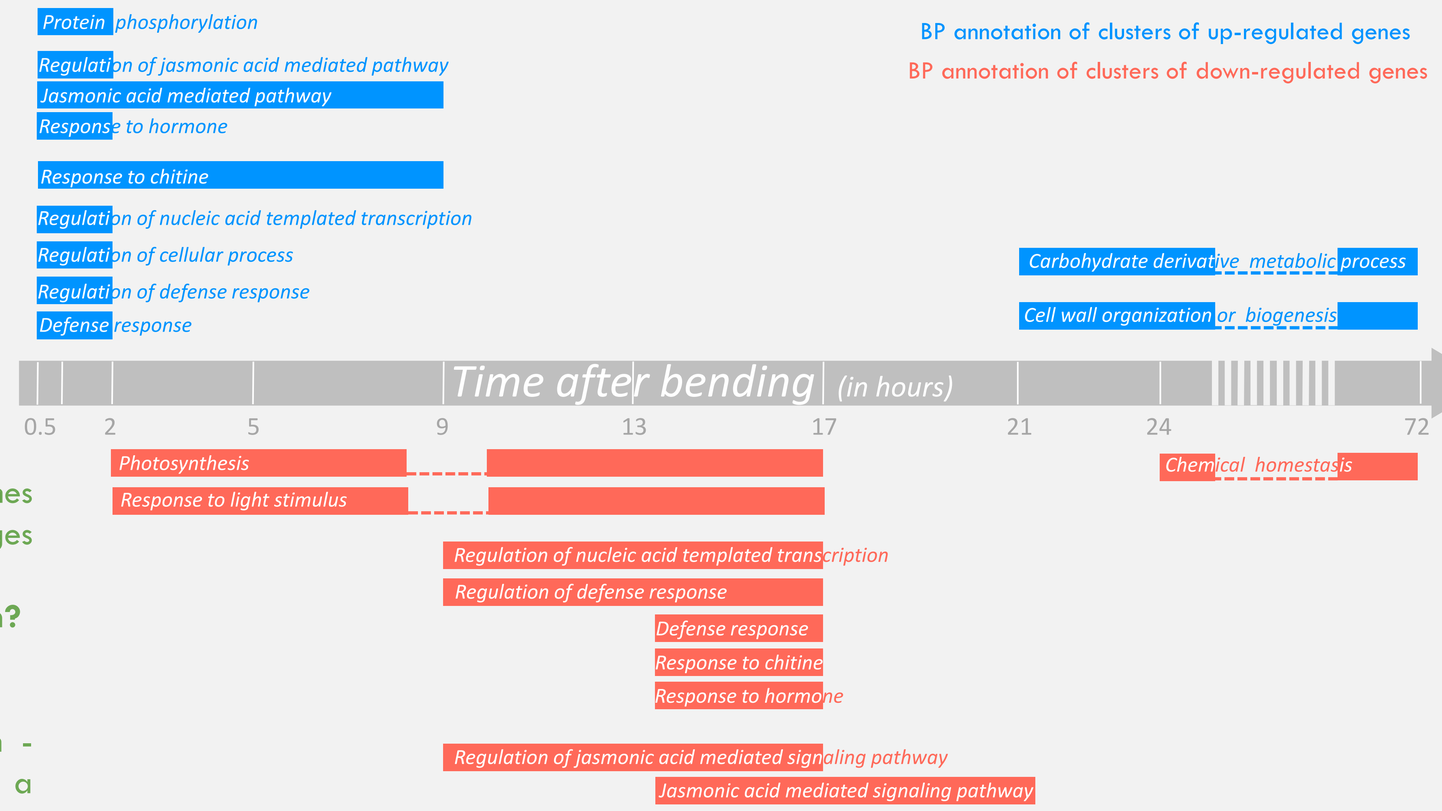
Example: Cluster 4
31 genes up-regulated 0,5h after 1 bending with a transcription factor activity GO affiliation.



Refinement of the early time course analysis for the biological processes involved

Refined time course analysis using **Q-PCR** → 6 extra time points between 0,5 h and 24 h for representative genes of each cluster

Chosen **genes represent** the **temporal patterns** and the **GO annotations** of the cluster.



BP annotation of clusters of up-regulated genes

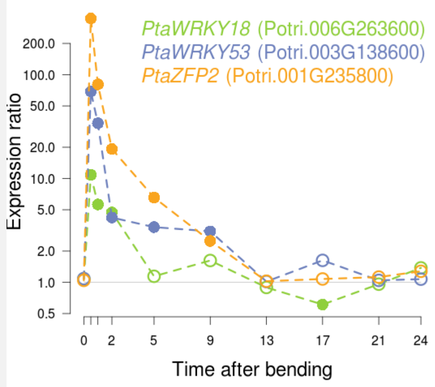
BP annotation of clusters of down-regulated genes

•**Early regulated genes** are related to "stress response":
- Transcription factors families (e.g. fig. A);
-Jasmonic acid and ethylene signaling (e.g. *fig. B*).

•Some early up-regulated genes are down-regulated in later stages (see *PtaJAZ2 fig. B*)
→**negative feedback mechanism?**

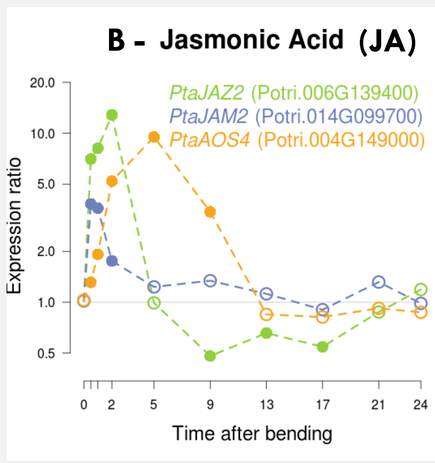
•**Late up-regulated** genes (21 h - 72 h), seem to be linked to a remodeling of cell wall-related processes.

A - Transcription Factor



PtaWRKY18, *PtaWRKY53*, *PtaZFP2 (C2H2)*: transcription factors

B - Jasmonic Acid (JA)



PtaJAZ2, *PtaJAM2* JA-induced transcription factors, negative regulator of JA responses
PtaAOS4, allene oxide synthase, JA biosynthetic pathway

Toward a better understanding of the accommodation process

Objectives: to investigate the extent of the molecular accommodation and to identify potential molecular actors.

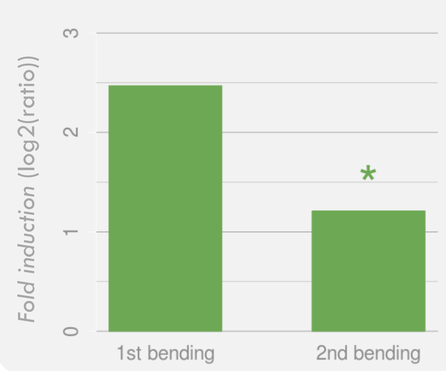
Gene expression 0.5 h after 1 bending **vs.** Gene expression 0.5 h after 2 bending (24 h interval)

96% of the **early regulated genes** after a 1st bending **are less regulated** after a 2nd bending

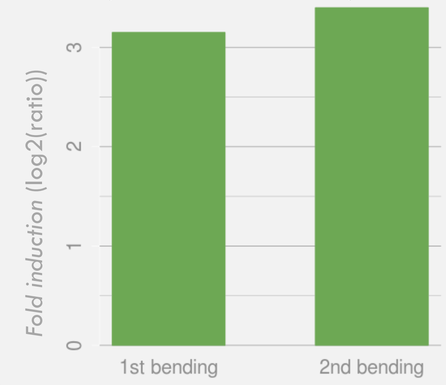
This mechanism may allow the plant to **avoid over-reaction** to successive bending.

3 types of genes:

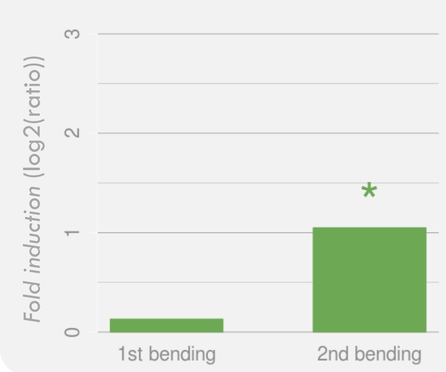
Accommodated
Less regulated after the 2nd bending, than after the 1st one.
1,098 genes
Example : PtaWRKY18 (Potri.006G63600)



Non Accommodated
Equally regulated after the 2nd bending, than after the 1st one.
44 genes
Example : PtaHRD (Potri.006G021000)



Newly Regulated
Regulated after the 2nd bending only.
18 genes
Example : PtaPEROX (Potri.007G096200)



***Perspectives* : We are currently working on new methods of gene network inference to understand the fine regulation of this mechanical signaling pathway.**

[1] C. Coutand, L. Martin, N. Leblanc-Fournier, M. Decourteix, J.-L. Julien, and B. Moulia. 2009. "*Strain mechanosensing quantitatively controls diameter growth and PtaZFP2 gene expression in poplar*". Plant Physiol. 151(1): 223–32
[2] L. Martin, N. Leblanc-Fournier, J.-L. Julien, B. Moulia, and C. Coutand. 2010. "*Acclimation kinetics of physiological and molecular responses of plants to multiple mechanical loadings.*" J. Exp. Bot. 61(9): 2403–12
[3] N. Leblanc-Fournier, L. Martin, C. Lenne, and M. Decourteix. 2014. "*To respond or not to respond, the recurring question in plant mechanosensitivity.*" Front. Plant Sci., 5: 401
[4] R. J. Haarsma, W. Hazeleger, C. Severijns, H. de Vries, A. Sterl, R. Bintanja, G. J. van Oldenborgh, and H. W. van den Brink. 2013. "*More hurricanes to hit western Europe due to global warming*". Geophys. Res. Lett., 40(9): 1783–1788

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