Mechanical properties of flexure wood

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Context and objectives

Trees adjust their development to the fluctuating mechanical conditions they experience (Telewski (1989), Pruyn (2000), Kern (2005)). Storms events of last decades showed that acclimation of trees to mechanical stresses due to wind is a very important process that allows trees to sustain for long years. In the future, trees will experience new wind patterns regarding frequency and intensity (Haarsma (2013)). Moreover, these patterns will go along with drought periods (Chauveau (2013)) that may impair the capacity of trees to adjust their wood properties to mechanical stresses due to wind. It is necessary to understand the mechanisms of wood functional acclimations to environmental conditions in order to predict their behaviour and in order to give foresters and breeders the relevant tools to adapt their forest management. This work aims to study how trees adjust the mechanical properties of their wood to environmental stresses and how this acclimation may be beneficial for the tree to resist to future stresses.

Material and methods

Young poplars were grown under controlled climatic conditions that include permanent environmental stress (daily mechanical stress of the stem by bending and/or hydric stress). Then, the properties of wood formed under these stressed conditions were characterized. First, we developed an original setup to cut millimetric samples of wood at the intra-ring level. Secondly, we designed micro-mechanical tests (micro-bending test and Charpy impact test, Fig. 1) in order to locally measure mechanical behaviour at the tissue scale (elastic modulus, elastic limit, damaging, and rupture energy).

Results and discussions

These experimental data allowed to evaluate the impacts of periodic stem bending on the mechanical properties of green wood. At the intra-ring level, we distinguished the wood formed under compressive or tensile stresses. They show that stem bending generates the formation of a wood that is less vulnerable to damaging with a weaker specific modulus: this phenomenon is probably due to compressive strength that endures wood during its development. Finally, we show that severe hydric stress does not degrade the acclimation of wood mechanical properties to stem bending.

Conclusions and perspectives

Our work enlightens that acclimation of trees is a priority requirement for its survival i.e. trees adapt their wood mechanical properties to withstand mechanical perturbations even in drought conditions. Furthermore, it also shows that the acclimation to stem bending increases trees capacity to sustain mechanical stresses during wind events.

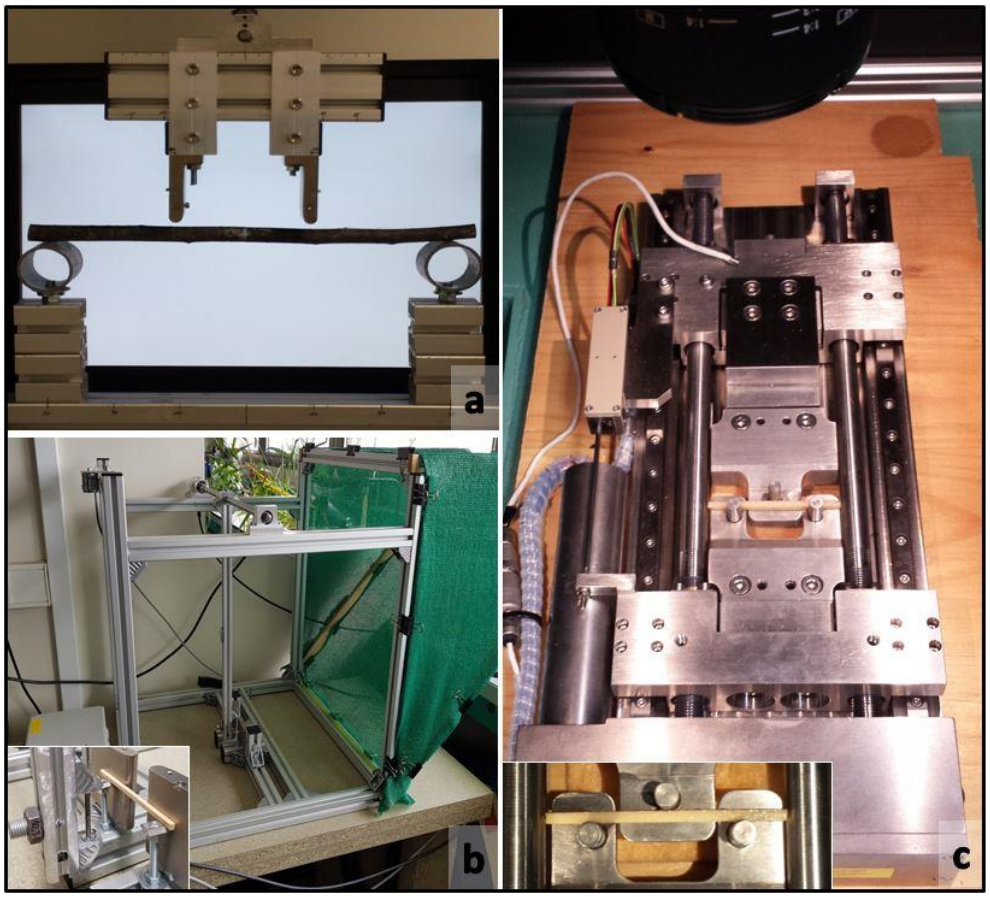

Fig. 1 : (a) Four points bending test on stem (34 cm length); (b) Charpy impact test on green wood matches (2×2×70 mm^3); (c) Micro-bending test on green wood matches (2×2×50 mm^3)

Références

Chauveau, M., S. Chazot, C. Perrin, P.Y. Bourgin, E. Sauquet, J.P. Vidal, N. Rouchy, E. Martin, J. David, T. Norotte, P. Maugis and X. de Lacaze. 2013. What will be the impacts of climate change on surface hydrology in France by 2070? Houille Blanche-Revue Internationale De L Eau:5-15.

Haarsma, R.J., 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. Geophysical Research Letters. 40:1783-1788.

Kern K.A., Ewers F.W., Telewski F.W., Koehler L. (2005) Mechanical perturbation affects conductivity, mechanical properties and aboveground biomass of hybrid poplars, Tree Physiology, 25:1243-1251

Pruyn M.L., Ewers B.J., Telewski F.W (2000) Thigmomorphogenesis: changes in the morphology and mechanical properties of two Populus hybrids in response to mechanical perturbation, Tree Physiology, 20:535-540

Telewski F.W. (1989) Structure and function of flexure wood in Abies Fraseri, Tree Physiology, 5:113-121