STReESS - Studying Tree Responses to extreme Events: a SynthesiS

STSM Report

Variability of xylem cavitation resistance in different European beech provenances

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Purpose of the STSM

European beech (*Fagus sylvatica* L.) is the most widely distributed forest tree species in Europe and is highly interesting for both economic and ecological reasons. The expected climatic changes, due to anthropogenic warming, might negatively affect beech growth and survival. Improving drought resistance has become a major issue, to prevent productivity decline and local extinctions of species in a context of climate change (Lindenmayer et al. 2012). According to recent studies, xylem cavitation resistance is associated with the capacity of tree species to survive extreme drought events (Brodribb et al. 2010; Urli et al. 2013). In addition, global surveys of cavitation resistance in woody species showed that xeric species are more resistant to embolism than hydric species (Choat et al. 2012). However, genetic variability and phenotypic plasticity have been little studied so far (but see Lamy et al. 2011, Lamy et al. 2013). The main objective of the STSM was to evaluate variability in cavitation resistance within and across marginal populations of beech. Moreover, we hypothesize that the southernmost populations, experiencing severer drought events, are more resistant to cavitation than populations from the core and Northern of Europe.

Description of the work

From March to May 2014, branches were collected from randomly selected trees from 15 populations across Europe. Branches, 1-3 years old, were collected during morning time, from the sunlight, upper third part of tree crowns. In each population, two branches were collected from 10 individuals, wrapped into wet paper and placed into sealed plastic bag for

transportation. Immediately after collection, samples were sent to the high-throughput phenotyping platform (http://sylvain-delzon.com/caviplace, UMR BIOGECO, University of Bordeaux, France) for cavitation measurements and were then stored at 5°C until processing. Study involved mostly marginal beech populations, as it is expected that marginal populations might provide the frontiers for adaptation, evolution and range shifts of plant species under the anticipated climate change conditions (Chhatre and Rajora, 2014).

Vulnerability curves were obtained using the CAVITRON technique (Cochard et al. 2005; Delzon et al. 2010) in order to estimate P50 for each population (proxy of cavitation resistance corresponding to the xylem pressure inducing 50% loss of hydraulic conductance). During the STSM samples from 10 populations were completed (Figure 1).

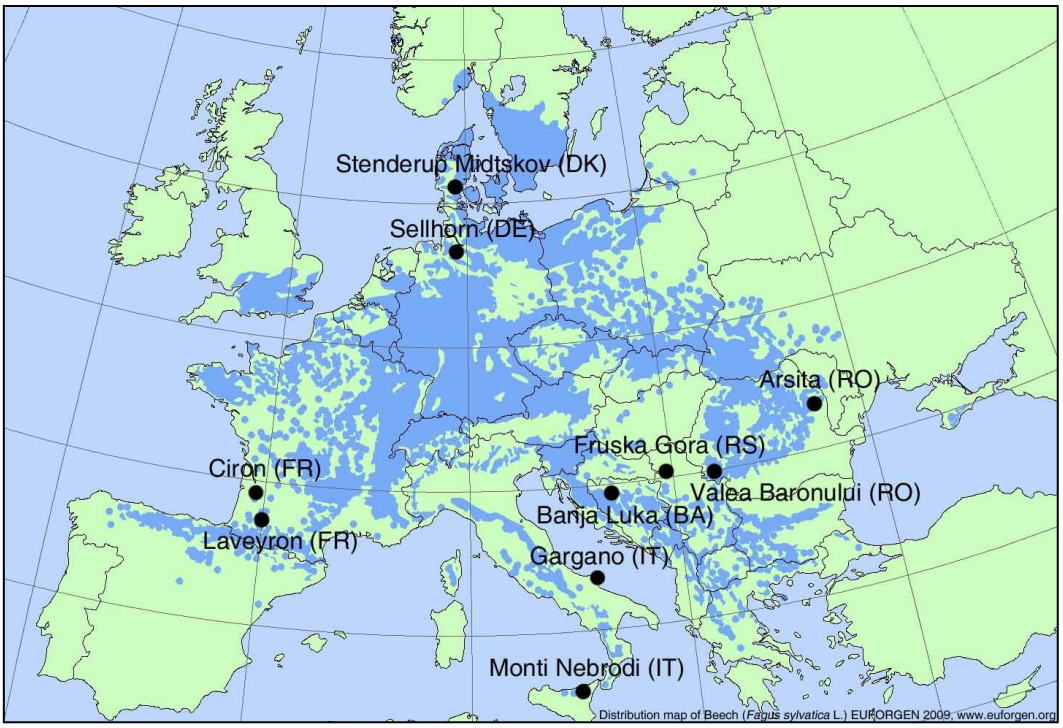

Figure 1. Populations sampled in the study.

The data were processed in SAS software (SAS Institute Inc.). The mean P_{50} values among populations were compared using one-way ANOVA.

Analysis of the early results

Mean value of P_{50} for all the populations studied ranged between −2.84 and −3.59 MPa, while the coefficient of variation amounted 7.33% (Table 1). This result is in agreement with the findings of Wortemann et al. (2011) that reported values of P_{50} ranging between -2.8 and −3.2 MPa, with a CV of 4.12%.

Table 1. Cavitation resistance (P_{50}, MPa) in studied beech populations.

Population	Country	P_{50}
Banja Luka	Bosnia	-3.59
Stenderup, Midtskov	Denmark	-2.84
Ciron	France	-3.00
Sellhorn	Germany	-2.99
Gargano	Italy	-3.22
Monti Nebrodi	Italy	-3.29
Laveyron	France	-3.55
Valea Baronului	Romania	-3.24
Arsita	Romania	-3.20
Fruska Gora	Serbia	-3.17

We evidenced significant differences between the beech populations studied. The lowest P_{50} values were observed in two northern populations: Stenderup, Midtskov (Denmark) and Sellhorn (Germany) (-2.84 and -2.99 MPa, respectively) and French population Ciron (-3.00 MPa). Populations from Bosnia and Herzegovina (Banja Luka) and France (Laveyron) were the least vulnerable to cavitation. P_{50} in these two populations amounted -3.59 and -3.55 MPa, respectively. In the rest of provenances mean P_{50} varied in the range between -3.17 and -3.29 MPa.

Implication for the Action aims

Resistance to cavitation is a major determinant of plant survival under severe drought and can be used to quantify species adaptive potential (Lamy et al. 2014). Moreover, marginal populations represent a great potential for European forests under climate change, that need to be taken into account in national and pan-European forest plans and strategies for adaptation and mitigation.

Assessment of the capability of different beech populations to cope with and adapt to drought stress is of crucial importance to predict future performance of species and to anticipate on enhanced stress events by adapted forest management. Our results suggest that southernmost populations are more cavitation resistant, comparing to populations originating from northern part of Europe and may then be used for afforestation programes of drier sites.

Dissemination of the results

The results obtained will be published in the scientific journal with the impact factor. Also, the results will be presented at the COST event A scientific roadmap for projections of global change impacts on forests, which will be held in Sarajevo, Bosnia and Herzegovina (27-28 August 2014).

References

1. Brodribb, T.J., Bowman, D., Nichols, S., Delzon, S., Burlett, R. (2010). Xylem function and growth rate interact to determine recovery rates after exposure to extreme water deficit. New Phytologist 188, 533-542.
2. Chhatre, V.E., Rajora, O.P. (2014). Genetic Divergence and Signatures of Natural Selection in Marginal Populations of a Keystone, Long-Lived Conifer, Eastern White Pine (*Pinus strobus*) from Northern Ontario. PLoS ONE 9(5): e97291. doi:10.1371/journal.pone.0097291
3. Choat, B., Jansen, S., Brodribb, T.J., Cochard, H., Delzon, S., Bhaskar, R., Bucci, S.J., Feild, T.S., Gleason, S.M., Hacke, U.G., Jacobsen, A.L., Lens, F., Maherali, H., Martínez-Vilalta, J., Mayr, S., Mencuccini, M., Mitchell, P.J., Nardini, A., Pittermann, J., Pratt, R.B., Sperry, J.S., Westoby, M., Wright, I.J., Zanne, A.E. (2012). Global convergence in the vulnerability of forests to drought. Nature 491, 752–755.
4. Cochard, H., Damour, G., Bodet, C., Tharwat, I., Poirier, M., Ameglio, T. (2005). Evaluation of a new centrifuge technique for rapid generation of xylem vulnerability curves. Physiologia Plantarum 124, 410–418.
5. Delzon S., Douthe C., Sala A., Cochard, H. (2010). Mechanism of water-stress induced cavitation in conifers: bordered pit structure and function support the hypothesis of seal capillary-seeding . Plant, Cell & Environment 33: 2101–2111.
6. Lamy J.B., Delzon, S., Kremer, A. (2013). Adaptive potential-a partial insurance against climate change risks. MOTIVE Chapter IV, 22-27.
7. Lamy J-B., Bouffier, L., Burlett, R., Plomion, C., Cochard, H., Delzon, S. (2011). Uniform Selection as a Primary Force Reducing Population Genetic Differentiation of Cavitation Resistance across a Species Range. PLoS ONE 6, e23476.
8. Lamy, J. Delzon, S., Bouche1, P.S., Alia, R., Vendramin, G.G., Cochard, H., Plomion, C. (2014). Limited genetic variability and phenotypic plasticity detected for cavitation resistance in a Mediterranean pine. New Phytologist 201, 874–886.
9. Lindenmayer, D.B., Laurance, W.F., Franklin, J.F. (2012). Global Decline in Large Old Trees, Science 338, 1305-1306.
10. Urli, M., Porté, A.J., Cochard, H., Guengant, Y., Burlett, R., Delzon, S. (2013). Xylem embolism threshold for catastrophic hydraulic failure in angiosperm trees. Tree Physiology 33: 672-683.
11. Wortemann, R., Herbette, S., Barigah, T.S., Fumanal, B., Alia, R., Ducousso, A., Gomory, D., Roeckel-Drevet, P., Cochard, H. (2011). Genotypic variability and phenotypic plasticity of cavitation resistance in *Fagus sylvatica* L. across Europe. Tree Physiology 31, 1175–1182.

This report may be posted on the Action website.