STReESS – Studying Tree Responses to extreme Events: a SynthesiS
COST Action FP1106

Short-Term Scientific Mission - Report

# Lethal drought tolerance of central and marginal beech provenances

**COST STSM Reference Number:** COST-STSM-FP1106-20275

**Beneficiary:** Eva Pšidová, Institute of Forest Ecology of the Slovak Academy of Sciences, Zvolen; evkapsidova@yahoo.com; psidova@sav.savzv.sk

**Host:** Prof. Dr. Andreas Bolte, Institute of Forest Ecosystems, Eberswalde; andreas.bolte@ti.bund.de

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## Introduction

The current frequency and intensity of extreme drought events across Europe is greater than in the past; thus, the ability of trees to recover from drought damage and to survive periods of drought is attracting increased attention (Galle and Feller 2007). In recent decades, an increasing frequency of warming during the spring and a subsequent increase in the occurrence of dry periods in the summer has been observed. Precipitation deficits in the winter and early spring results in weak supplies of water, resulting in subsequent water deficits during the vegetation period. (Welp et al. 2007, Allen et al. 2010). Water deficit, the most common natural environmental limit associated with water stress, is the factor controlling the production and determination of the distribution of the European beech (Silva et al. 2012).

Based on the 'physiological drought' concept (cf. Kursar et al., 2009), we follow a 'lethal dose' approach, related to remaining soil water content (SWC, cf. Czajkowski et al., 2009) for regeneration of European beech as one of the major tree species in Europe. A lethal impact dose for plant collectives is normally defined as a threshold of 50% mortality. By applying this concept, the soil water deficit in the effective rooting depth (ERD), where 50% mortality in forest tree populations occurs, can be used for determining the $L50_{SWc}$. This $L50_{SWD}$ indicator can be easily implemented in combined climate and soil water models in order to assess potential sensitivity of different forest tree species or species provenances to (future) increased drought events.

Due to several findings that 'rear edge' provenances of European beech are less sensitive to drought impacts then those within the central continuous range (e.g. Tognetti et al., 1995; Bolte et al. 2007; Rose 2009) we plan to conduct a 'lethal dose' experiment using beech seedlings of different 'rear edge' and 'central' provenance. From the results we want to derive a common $L50_{SWC}$ evaluation for European beech throughout its natural range in Europe.

## Purpose of the STSM

The aim of the STSM was to conduct a 'lethal dose' experiment using beech seedlings of different European provenances. From the results we want to derive a common L50SWD evaluation for European beech throughout its natural range in Europe. My participation contributed research by chlorophyll fluorescence measurements and relative chlorophyll content measurement.

## Description of the work

The potted seedlings were located in the greenhouse (1-year-old-seedlings, 7 provenances, Fig. 1). Before the experiment starts, all pots were watered until water saturation is reached and then weighted in order have an initial value for water losses due to evapotranspiration. In addition, we assessed the water status of all seedlings.

Two groups of plants were established: a control group (24 plants per provenance) watered regularly and a treatment group not watered during the drought experiment. Water irrigation for treatment plants was stopped the 6$^{th}$ of August. From this date pot weight of each plant was measured two times per week in order to estimate soil water content and plant survival was checked, also.


Fig. 1 Greenhouse


Fig. 2 Seedlings (*Fagus sylvatica* L.)

We measured the Predawn water potential (Scholander pressure chamber, Fig. 5), transpiration and assimilation status (porometer measurements), changes in the efficiency of primary photochemistry in PS II (fast and slow kinetics of chlorophyll *a* fluorescence) and relative chlorophyll content (´Chl index`, Fig. 3).

We used Handy Pea fluorometer (Hansatech Ltd., Kings Lynn, UK) for measurements fast kinetics of chlorophyll *a* fluorescence. We assess maximal fluorescence yield ($F_v/F_m$), photosynthetic performance index (PI).


Fig. 3 Measurement of Chlorophyll 'index'


Fig. 4 Dead and live seedlings

A MINI-PAM photosynthesis yield analyzer (Heinz Walz GmbH, Effeltrich, Germany) records Rapid Light Curves (RLCs) for assesses slow kinetics of chlorophyll *a* fluorescence. The MINI-PAM records all relevant fluorescence parameters: effective quantum yield ($\Phi_{PSII} = \Delta F/Fm'$); electron transport rate (ETR) values at a given actinic irradiance PAR ($ETR = \Phi_{PSII} \times PAR \times 0.5 \times 0.84$), where 0.5 is a multiplication factor for two quanta of light required for the transport of one electron, and 0.84 is the species-specific fraction of incident quanta absorbed by the leaf; photochemical quenching (qP), non-photochemical quenching (qN) and a parameter describing non-photochemical quenching (NPQ) assuming a matrix model of the antenna system based on Stern-Volmer quenching.


Fig. 5 Measurement of water potential

We measured Relative chlorophyll content (Fig. 3) using the CL-01 Chlorophyll Content Meter (Hansatech Ltd., Kings Lynn, UK), which determine the relative content using dual wavelength optical absorbance (620 nm and 940 nm) expresses as a ´Chl index`.

## Preliminary results

Most of the collected data are currently being analysed. For this time are available, preliminary results related to survival rate of studied provenances and relative chlorophyll content.

Preliminary survival rate (%) sorted by provenance shows Fig. 6. The seedlings from French and Spanish provenance have the best survival rates.

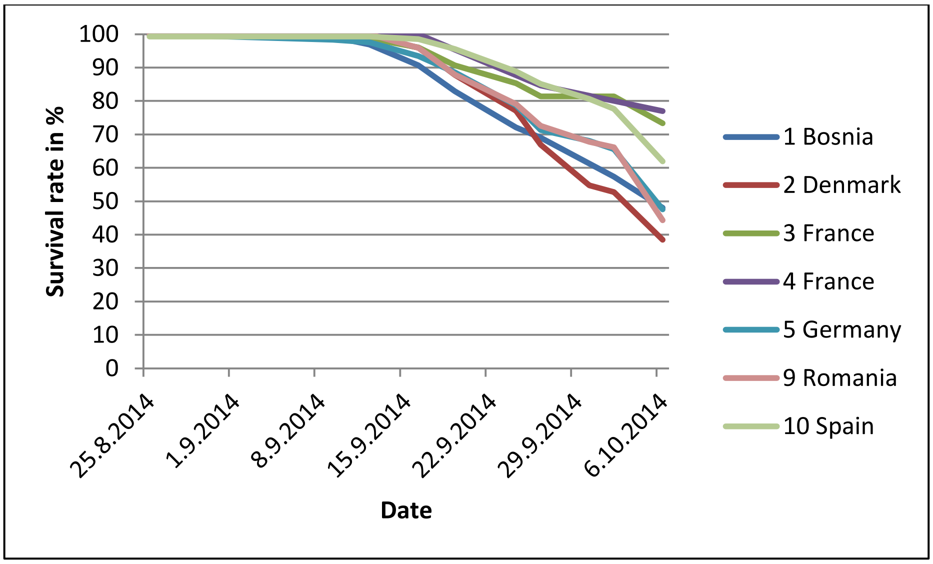


Fig. 6 Preliminary survival rate (%) sorted by provenance.

Preliminary results of survival rate correspond to the recorded data of relative chlorophyll content (Fig. 7). At seedlings origin from Denmark and German provenance was observed more significant decrease of Chlorophyll 'index', compared to another studied provenances. Based on presented preliminary results we assume that consequence analyses of changes in the efficiency of primary photochemistry in PS II (fast and slow kinetics of chlorophyll *a* fluorescence) will show more detail information about drought sensitivity of beech provenances and supposed differ drought impact to photosynthesis efficiency and stomatal control.

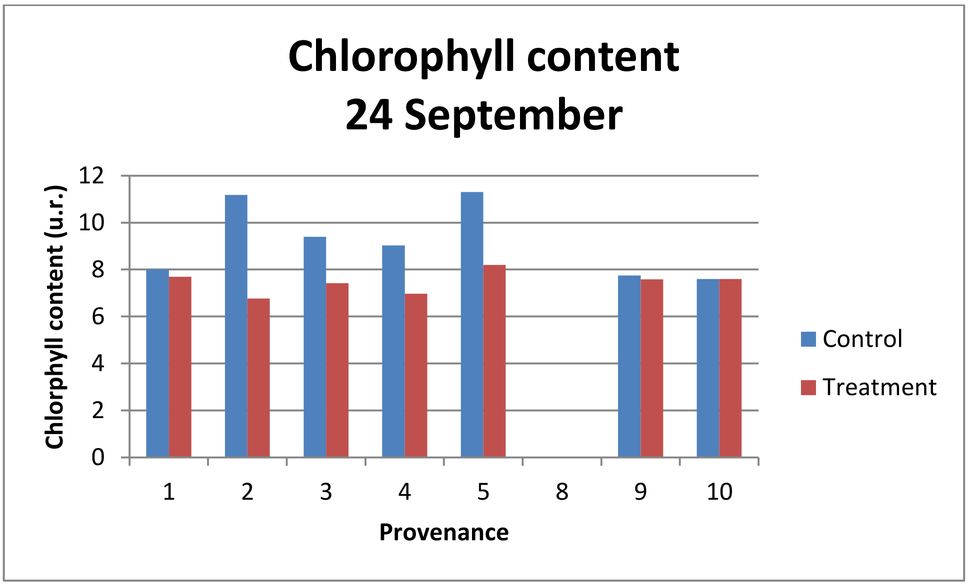


Fig. 7 Relative chlorophyll content – Chlorophyll 'index' (u.r.) sorted by provenance. (Legend for origin of provenances is in Fig. 6)

## Implication for the Action aims

STSM followed the intention of WG3 and TG3 (Lethal dose of drought) - to study ecological thresholds of lethal drought impacts on young beech from different European origins. STSM was focused on experimental studies with beech seedlings from 7 provenances. The L50 SWD indicator obtained from the results of this STSM can be implemented in combined climate and soil water models in order to assess potential sensitivity of different provenances to future increased drought events. With this new information the potential of beech forests adaptation by using introduced provenances could be assessed

Results will be used for identifying research gaps and needed integrative research activities on lethal drought adaptation of different tree species and their provenances relevant for differ biomes throughout Europe. This may an important part of a joint research proposal of the COST STREeSS group.

## Acknowledgements

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**This report can be posted at the COST Action website.**

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