THE ROLE OF LIVING BARK IN *BETULA PENDULA* ABILITY TO REFILL EMBOLISED XYLEM

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INTRODUCTION

Embolism formation and its potential run away spreading through the plant vascular system has received a lot of attention in the recent years, as it appears central to the observed drought-induced mortality of trees. However, the tree ability to recover from such embolism has received less attention. In particular, the tree ability to refill embolsim causes by drought or freezing stress is under debate in the last recent years. This debate has been fuelled by the discovery that some earlier method used to assess tree embolsim and refilling ability were prones to artefact (e.g., Wheeler et al. 2013). And if or when refilling happens, the mechanisms allowing it remains unknow despite several hypothesis (Nardini et al. 2011).

However, our recent studies have nonetheless shown that silver birch (*Betula pendula*) might be able to refill (Salmon et al. 2018), and hypothesised that it might be related to its abilty to pressurised sap in the spring prior to budbusrt (Hölttä et al. 2018). These earlier studies let to two hypothesis about the mechanisms involved in the refilling process: 1) the phloem in the living bark plays a role in initiating the refilling; 2) the refilling process is an activate process involving energy cost for the tree, which are supplied by the stored starch and non-structural carbohydrates.

We conducted an experiment to test these two hypothesis and further explore the mechanims underlying birch refilling ability.

METHODS

Branches of silver birch were sampled at the greenhouse of the university of Helsinki, Viikki campus. The sampled branches were longer than70cm and without divisions. The sample was let to bench dry until fully embolsied and not conductive., with a water potential (Ψ) lower than -3 MPa (Choat et al. 2012)as controlled by water potential measurement of a 10 cm subsample with a pressure chamber. The samples were divided in two subsamples of more than 30cm length to avoid open vessels artefacts. One subsample was peeled of its bark, phloem and cambium and wrap with PTFE tap to limit evaporation and avoid leakage during the refilling experiment.

For each subsample, hydraulic recovery was induced with a small hydraulic positive pressure provided by a water column attached to the upper end of the branches held vertically on a stand. The amount of water flowing through each subsample was recoreded with balances to measured the restauration of the hydraulic conductivity.

After each measurments, a 5 to 10cm piece was cut from the subsamples and used to measured non-structural carbohydrates and starch concentrations. The cut piece was frozen in liquid nitrogen to stop enzymatic activity, dried and ground to powder and stored until analyses.The procedure continue with shorten sub-samples until the branches stopped being able to refill or became too short for futher measurments (I.e after a maximum of three refilling attempts).

We also measured the osmolality of the first drop of sap coming out of the refilling branches to assess whether refilling might have happen by loading sugars in the xylem to osmotically draw water from surrounding cells.

CONCLUSIONS

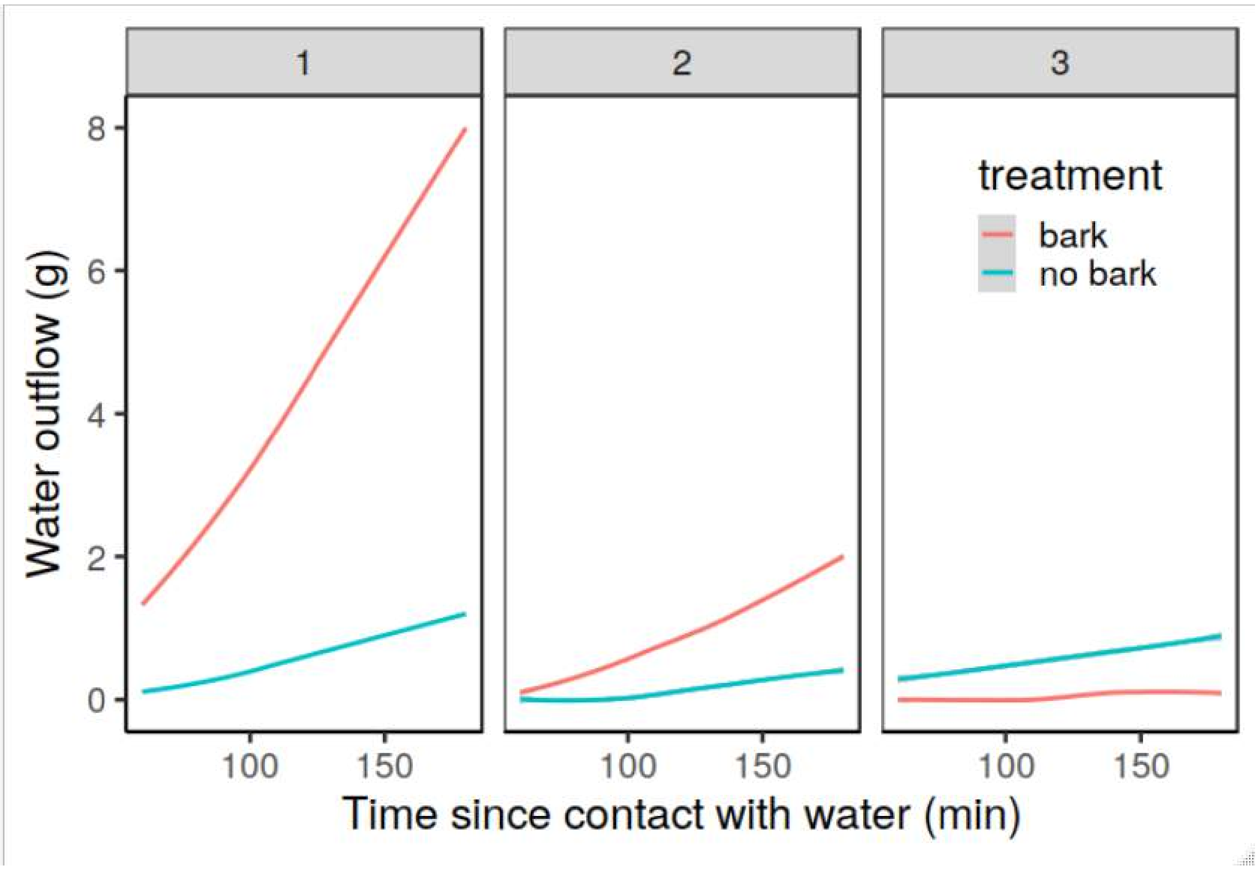

Figure 1: Amount of water conducted through a branch of silver birch as a function of time since the branches was put in contact with water per successive runs of embolism and refilling (1, 2 and 3) for sub-samples with the living bark intact ("bark", red) or with the living bark removed ("no bark", blue).

The preliminary results show the presence of living bark originally allows the studied branches to restore conductivity faster than the branches on which living bark at been removed (Fig. 1, panel 1). The refilling ability of branches with living bark clearly decline with the number of refilling events (compare runs 1, 2 and 3), eventually becoming smaller than that of the branches without bark.

The osmolality of the sap after refilling is not sufficient to explain the refilling through sugar loadings in the embolised xylem.

On-going measurments of non-strucutral carbohydrates and starch are expected to shed furhter light on the potential mechansisms underlying this differences between treatments as well as improve our understanding of the mechansisms underlying silver birch refilling ability.

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REFERENCES

Choat B., Jansen S., Brodribb T.J., Cochard H., Delzon S., Bhaskar R., Bucci S.J., Field T.S., Gleason S.M., Hacke U.G. et al. (2012). Global convergence in the vulnerability of forests to drought. Nature 491: 752–756

Hölttä, T., Dominguez, M., Salmon, Y., Aalto, J., Vanhatalo, A., Bäck, J. and A. Lintunen (2018). Water relations in silver birch during springtime. How is sap pressurized? Plant Biology, 20: 834-847.

Nardini, A., Lo Gullo, M.A., and Salleo, S. (2011). Refilling embolized xylem conduits: Is it a matter of phloem unloading? Plant Sciences. 180, 604-611.

Salmon, Y., Lintunen, A., Lindfors, L. Suhonen, H., Sevanto, S., Vesala, T. and T. Hölttä (2018). Silver birch ability to refill fully embolised xylem conduits under tension. Acta Horticulturae, 1222, 67-73.

Wheeler JK, Huggett BA, Tofte AN, Rockwell FE, Holbrook NM (2013) Cutting xylem under tension or supersaturated with gas can generate PLC and the appearance of rapid recovery from embolism. Plant Cell and Environment, 36, 1938-1949