Evaluation of a unilateral magnet to characterize water in root systems

Magali Nuixe [a,b,c#], Guilhem Pages [a,b], Jean-Marie Bonny [a,b], Catherine Pichon-Cochard [c], Amidou Traore [a,b]

[a] Université Clermont Auvergne, INRAE, UR QuaPA, 63122, Saint-Genès Champanelle, France; [b] INRAE, PROBE research infrastructure, AgroResonance facility, 63122, Saint-Genès-Champanelle, France, [c] Université Clermont Auvergne, INRAE, VetAgro Sup, UREP, 63000 Clermont-Ferrand, France, [#] present adsress : The Institute of Cancer Research 15 Cotswold Road, Sutton, SM2 5NG,

Grasslands and forests are the two main terrestrial ecosystems limiting the global warming thanks to their high capability to store carbon. Sap flows are playing a critical role by bringing the water and minerals used for transpiration and photosynthesis (xylem) from the roots to the leaves and transporting the photosynthetic carbons (phloem) to the carbon sinks (e.g., wood, roots, soil). In the context of global warming, a fine understanding of these transport mechanisms is necessary. However, a sensor able to locally probe water content and its movement directly on the plants in their ecosystem (i.e., in situ) does not exist yet.

To measure non-invasively and in a given spatial volume water properties, MRI is the analytical tool of choice. However, such instrument cannot be moved and only laboratory experiments can be performed. Recently, portable MRI have been developed [1]. To be able to move the MRI system, the magnetic field intensity is significantly decreased. Thanks to special design and tricks, few portable sensors can record the MRI signal in a slice having a thickness of few tenths of micrometers. After choosing one of these devices, the NMR-MOUSE [2], we designed a vector allowing to move it and to position it directly against the plant in any positions.

Our objective is then to evaluate the capabilities of this MRI sensor to measure water both repartition and flow in roots. Our experiments were performed on root systems of different grassland species grown as monocultures. We demonstrated that the MRI sensor was able to detect water content variation during the cycle day /night [3]. These circadian variations matched the reference methods used to obtain information on the root hydration: soil relative humidity and leaf water potential. These data were completed by local transversal relaxation time measurements. We observed a variation of the apparent T2 with the light cycle. We explained these variations by the plant water demand due to transpiration. We evaluated the capability of our sensor to monitor water content during a hydric stress as well as during the plant recovery after rehydration (Figure 1). The first results obtained on roots from different grassland species demonstrated the interest of this MRI sensor.

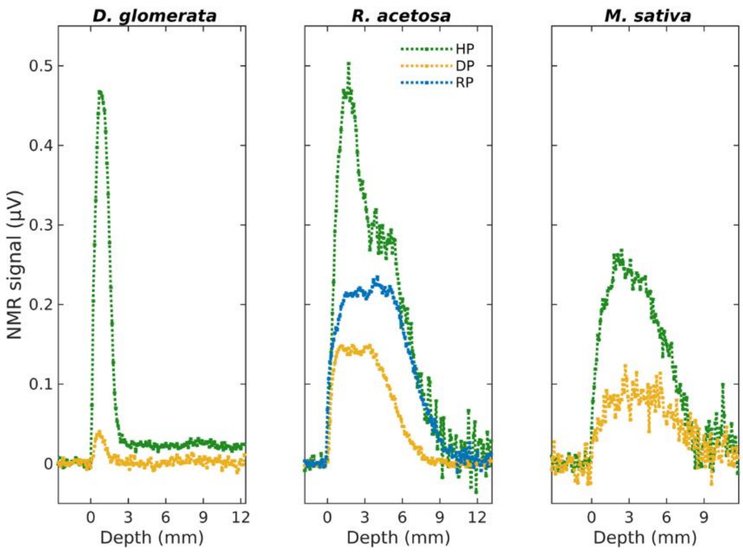

Figure 1 : Illustration of the MRI signal obtained on (a) *D. glomerata*, (b) *R. acetosa* and *M. sativa* in the well hydrated conditions (HP), in the drought conditions (DP, after 3 weeks without irrigation), and in the rehydrated conditions (RP, 200mL of water three times per day during 3 days).

References
[1] S. Blystone, M. Nuixe, A. S. Traoré, H. Cochard, C. Picon-Cochard, G. Pagés, Plant Meth. 20 (2024)
[2] Eidmann G., Savelsberg R., Blümer P. & Blümich B., *J. Magn. Reson. Ser A*, 122, 104, 1996
[3] Nuixe M., Traoré A., Blystone S., Bonny J.-M., Falcimagne R., Pagés G. & Picon-Cochard C., *Plants*, 10, 782, 2021