Redistribution of Arsenic by the Hydraulic Lift of the Black Willow (*Salix nigra*)

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Background

- **Arsenic** (As) is a ubiquitous and highly toxic metalloid for most forms of life, including plants and animals (Mandal & Suzuki, 2002).
- **Phytoremediation** is an innovative technology used to decontaminate soils (Pilon-Smits, 2005).
- Recent research has shown increased soil contaminants concentration after phytoremediation experiments.
- Plant roots are capable of redistributing water from moist to dry soil in a process called **hydraulic redistribution** (Fig. 1) (Liste & White, 2008).
- Among membrane proteins, some **aquaporins** facilitate the uptake and transport of water, but also of arsenic, indicating a similar pathway in plants (Zhao *et al.,* 2009).

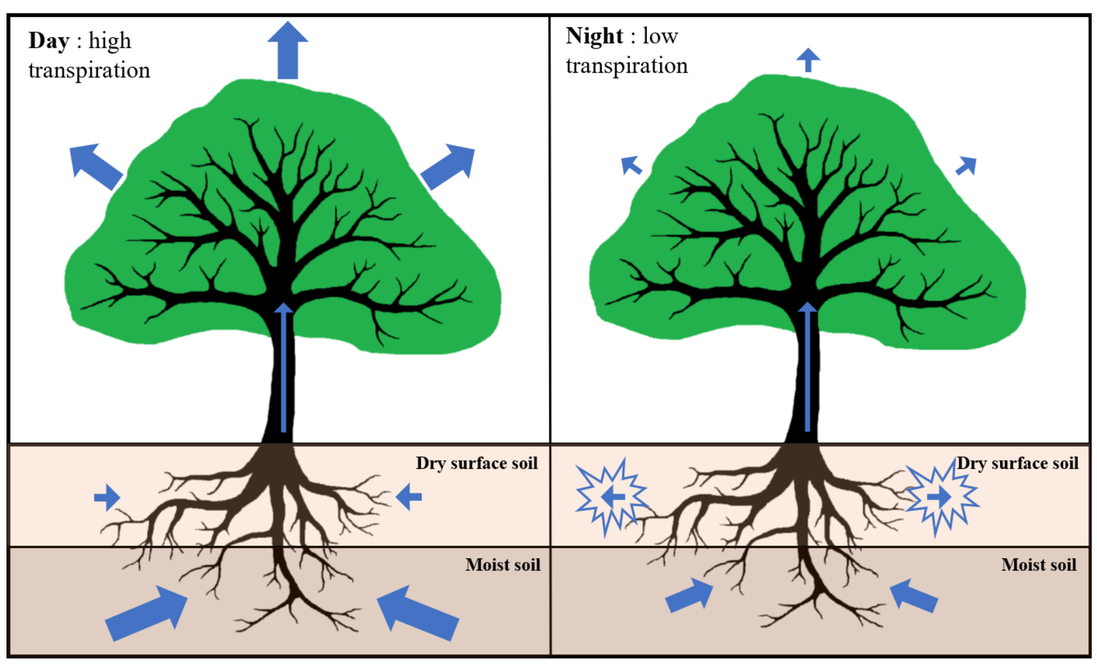

Figure 1. The hydraulic lift process in trees. This form of hydraulic redistribution moves water from deep moist soil towards the shallow soil that tends to dry up by evaporation, due to differences in water potential. Water flow is illustrated in blue.

Objectives

- Elucidate the role of **hydraulic movements** caused by **black willows** in the **distribution of arsenic** through the soil profile and the potential of **intercropping** with an As hyperaccumulator (*Pteris vittata*).
- Study the gene expression level and role of key **membrane proteins** involved in the movements of arsenic in black willows.

Experimental Design

- Redistributing plant : ***Salix nigra*** (cuttings)
- Arsenic hyperaccumulator : ***Pteris vittata***
- **Double-pot system** to separate deep and surface soil layers, isolate water/As movements in plants (Fig. 2)
- **9 treatments** (Fig. 3); **5 replicates** per treatment; 45 experimental units

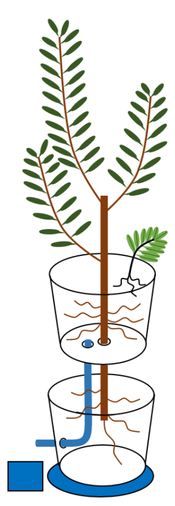

Figure 2. Diagram of the experimental units.

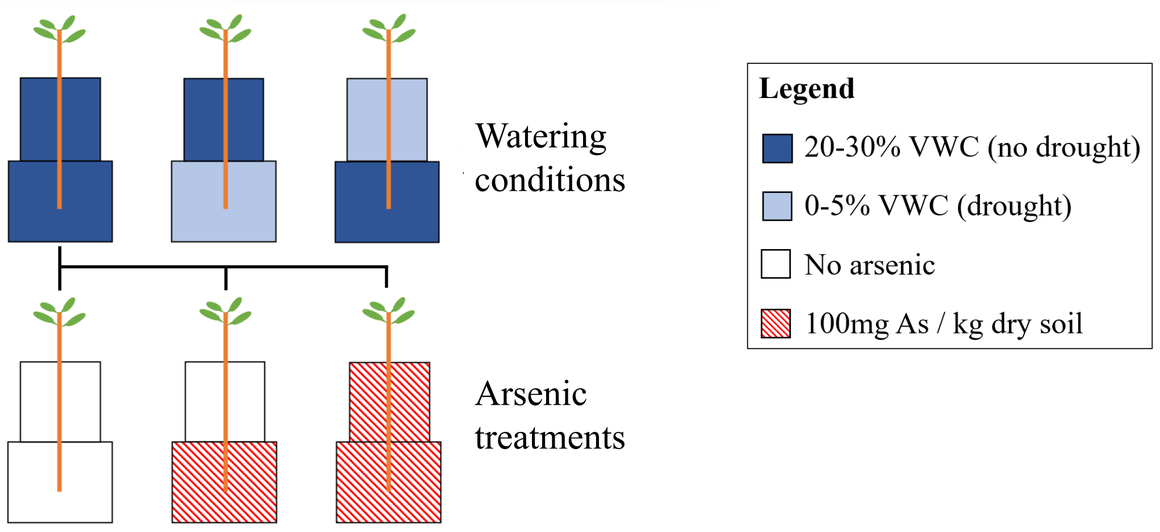

Figure 3. Diagram of the drought and arsenic treatments.

Results : As is redistributed towards drier soil through willow roots

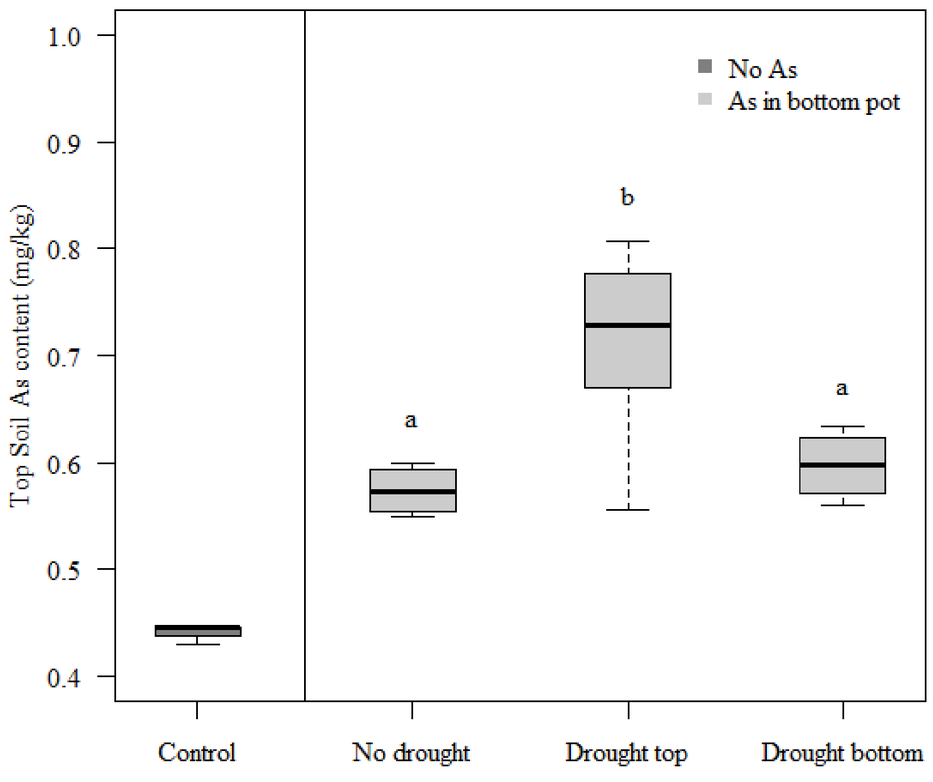

Figure 4. Soil As content (mg/kg) in the top pot of the double-pot systems. Treated pots were contaminated to 100 mg/kg of As in the bottom pot and put under different watering conditions. Control treatment consists of no contamination and no drought.

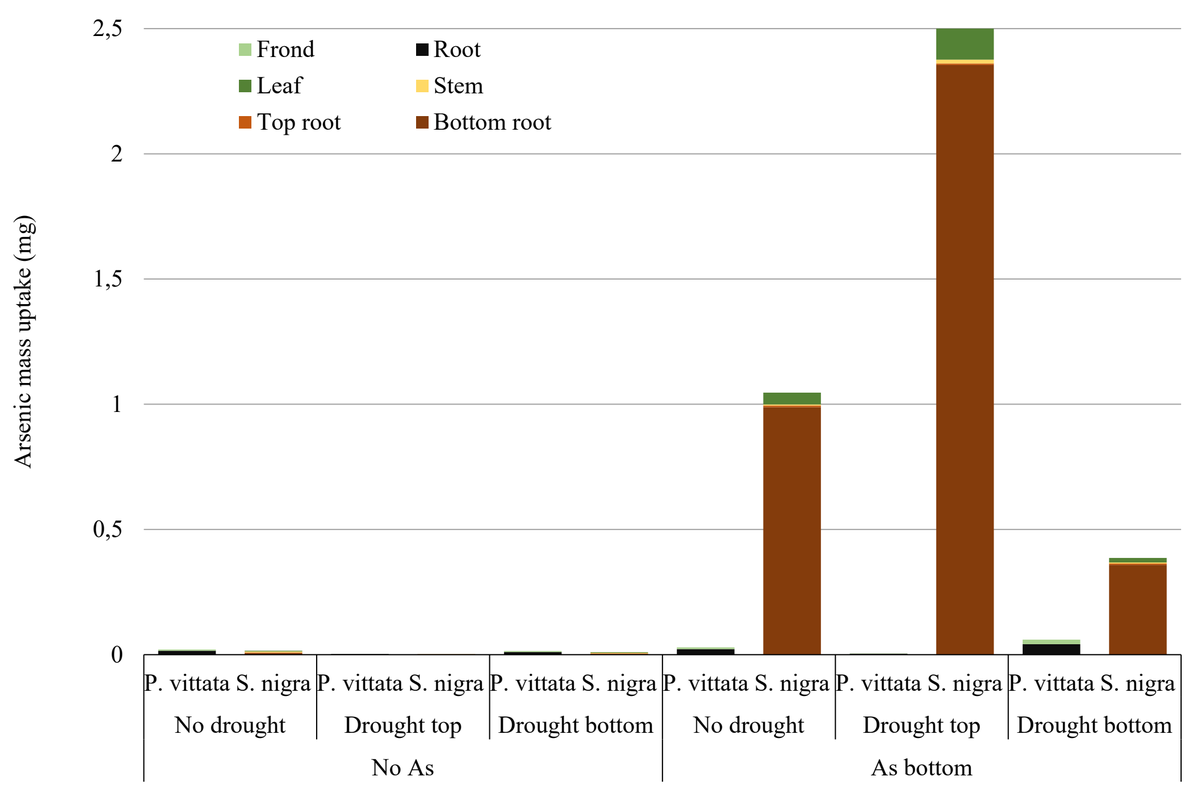

Figure 5. Mass of arsenic (mg) accumulated in plant tissues for the units treated no As or As added to the bottom pot (to a concentration of 100 mg/kg), the three different watering conditions

		Salix nigra		*Pteris vittata*	
As treatment	Drought treatment	Survival rate	Total biomass (mean ± SE in g)	Survival rate	Total biomass (mean ± SE in g)
Control	No drought	100%	18.20 ± 0.51	100%	4.74 ± 0.46
	Drought top	80%	20.45 ± 1.02	40%	1.79 ± 0.34
	Drought bottom	100%	14.65 ± 0.47	100%	2.69 ± 0.26
As in bottom pot	No drought	100%	13.20 ± 0.36	100%	2.50 ± 0.34
	Drought top	100%	23.19 ± 0.88	40%	2.40 ± 0.43
	Drought bottom	100%	12.17 ± 0.37	100%	3.44 ± 0.39

Figure 6. Survival rate (%) and mean of total biomass produced (g) by *Salix nigra* and *Pteris vittata* in units treated with no As or with As in the bottom pot.

Next Steps : understanding the underlying molecular mechanisms

- Measurement of willow root **gene expression levels** focused on aquaporins (**PIP & NIP**) and high-affinity phosphate transporters (**PHT1**) in response to drought and arsenic treatments : **RNA profiling**
- Analysis of aquaporin selectivity for arsenic transport by **heterologous expression in *Pichia pastoris***

References

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Zhao, F. J., Ma, J. F., Meharg, A. A., & McGrath, S. P. (2009). Arsenic uptake and metabolism in plants. *The New Phytologist*, *181*(4), 777–794.