Root development of non-accumulating and hyperaccumulating plants in metal contaminated soils amended with biochar

Frédéric Rees, Thibault Sterckeman, Jean-Louis Morel

ROOT DEVELOPMENT IN METAL CONTAMINATED SOILS AMENDED WITH BIOCHAR

Frédéric REES[1], Thibault STERCKEMAN[1], Jean-Louis MOREL[1]

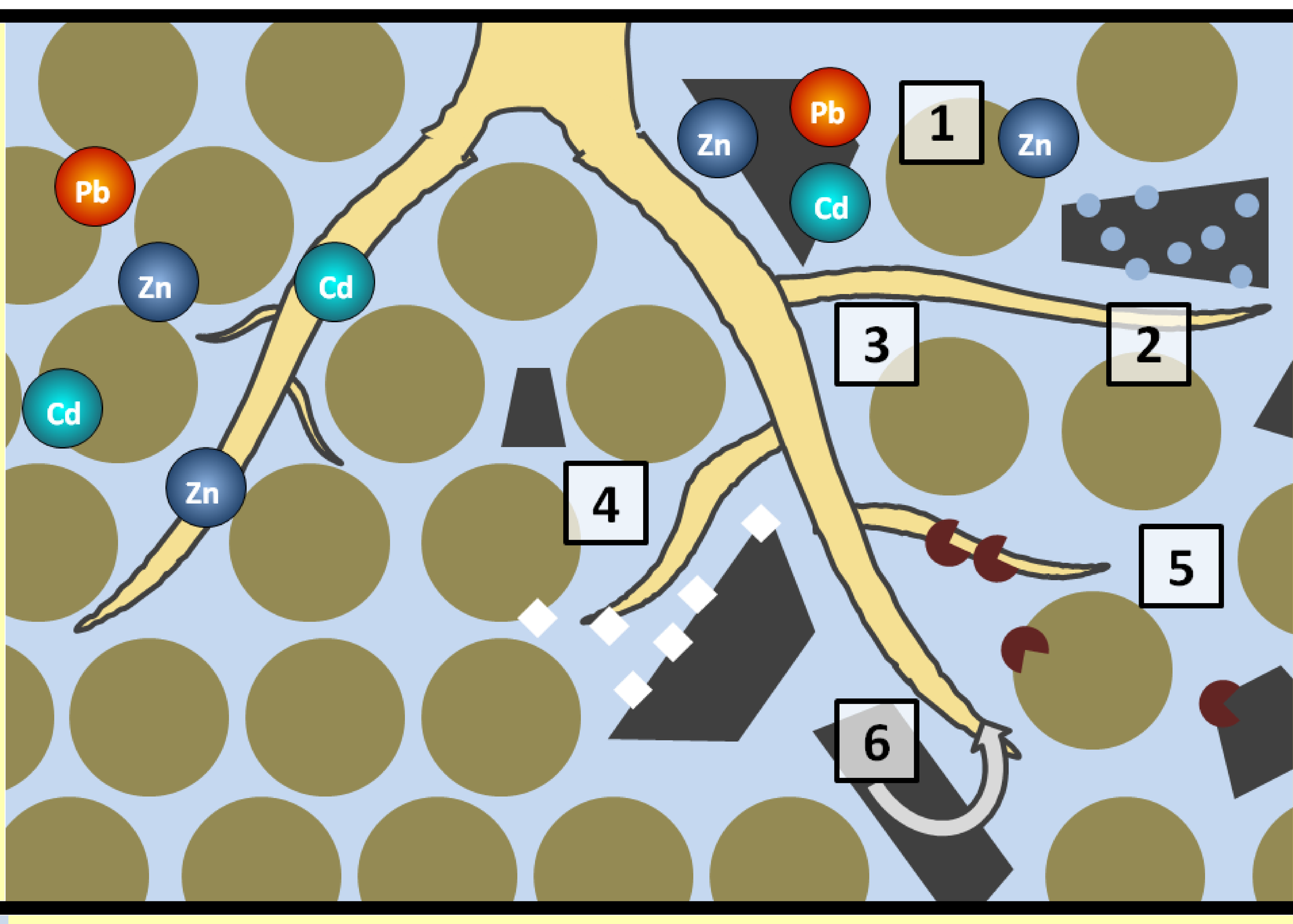
**corresponding author: Frédéric REES, f.rees@gisfi.fr*

[1]Université de Lorraine/INRA, Laboratoire Sols et Environnement
F-54500 Vandœuvre-lès-Nancy, France

INTRODUCTION

Biochar, the solid product from biomass pyrolysis used as soil amendment, has emerged as a promising carbon sink and soil improver. Its sorbent properties could also be used in the remediation of contaminated soils, particularly in **phytoremediation.**

Biochar's influence on **root growth** is however poorly known [1], *e.g.* for **soils contaminated with heavy metals**. An increase of root surface in those soils may lead to a **decrease of metal leaching**, as less water is percolating, but also to an **increase of metal uptake** by the plant, as the exchange surface between soil and plant is increasing.



In this context, several mechanisms [1,2,3] could explain a better root development:

[1] Soil **toxicity** ↘
[2] **Water** availability ↗
[3] Resistance to **root penetration** ↘
[4] **Nutrient** availability ↗
[5] Beneficial **microorganisms** are promoted
[6] Biochar induces plant **hormonal response**

➔ A **rhizobox** experiment was designed to:

1) Quantify the effect of biochar on **root growth in contaminated soils**
2) Identify a possible **root tropism** towards biochar, thanks to a specific design

MATERIALS

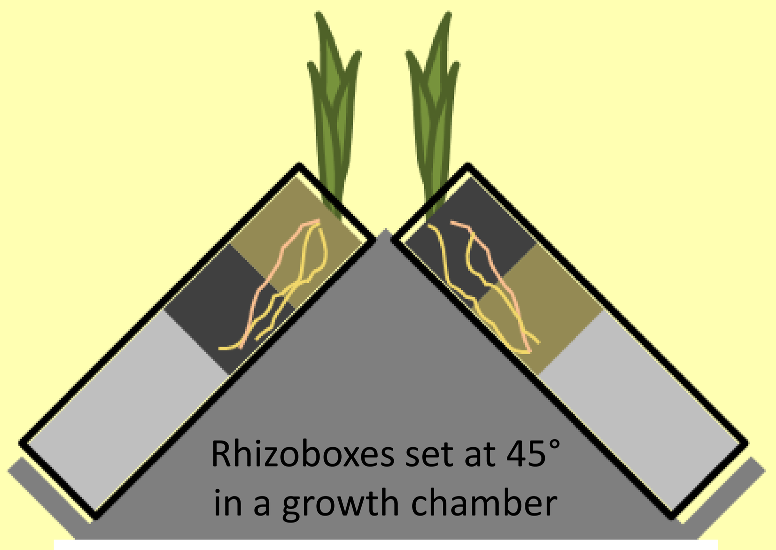
- **1 biochar** produced by Carbon Terra at ~450°C from woody biomass, <2mm, untreated (pH 9.2)
- **2 soils** contaminated with Cd, Zn, Pb, sampled near smelters, with similar properties but different pH.

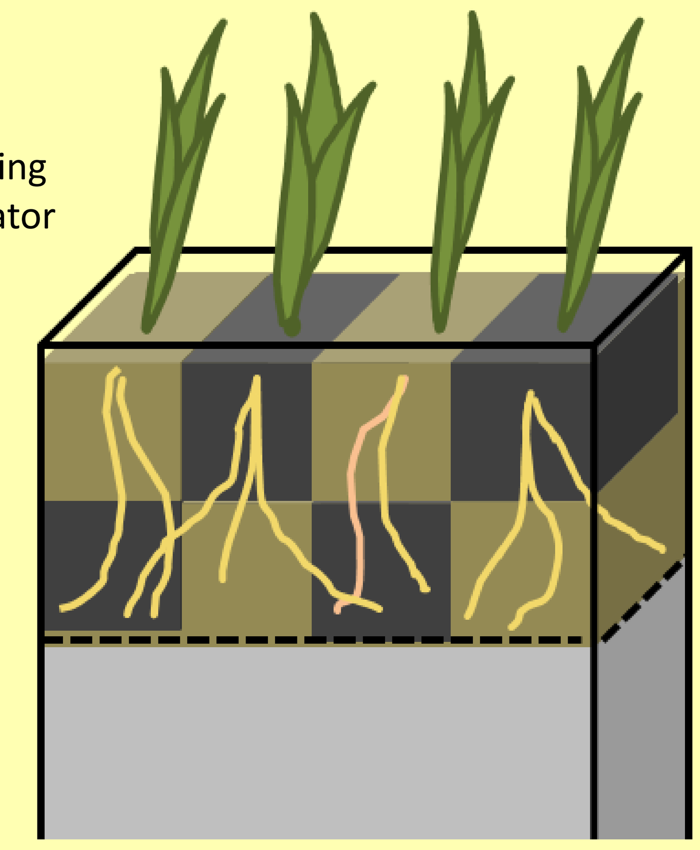
pH value and available (/ total) metals of soils (mg kg^{-1})

Soil	*pH*	Cd	Pb	Zn
Soil A	*5.9*	5.9 / 17.6	1.7 / 1120	684 / 3170
Soil B	*8.1*	0.24 / 18.6	0.06 / 1080	2.0 / 1380

→ With biochar, metal availability strongly ↘ on Soil A, but only slightly on Soil B due to its higher initial pH [4]

- **2 plant species** grown in large rhizoboxes:
- Zea mays, non hyperaccumulating, fast growing
- Alpine pennycress, Cd and Zn hyperaccumulator





METHODS

- 4 seedlings grown per rhizobox with 2000 g of soil, divided in 8 compartments as a **chessboard**:

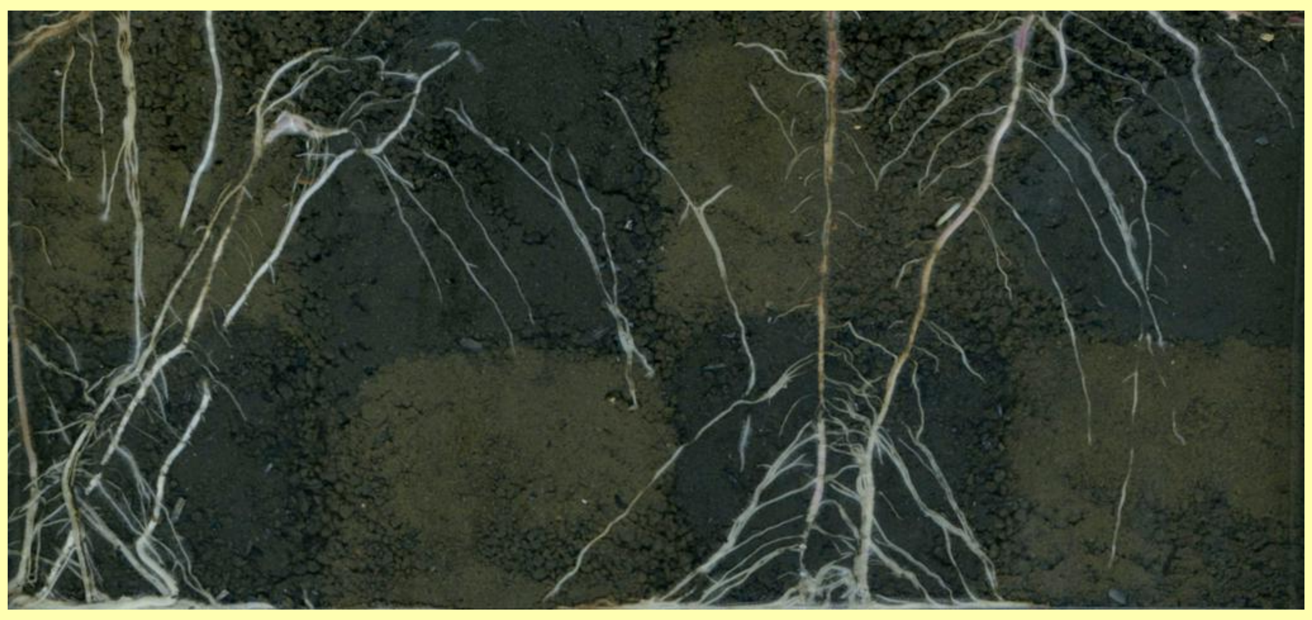
4 squares with pure soil
4 squares with soil + 5% (w/w) biochar

- 2 rhizoboxes for each plant and soil
- Daily watering at 85% of water holding capacity
- High-resolution scanning of the soil profile

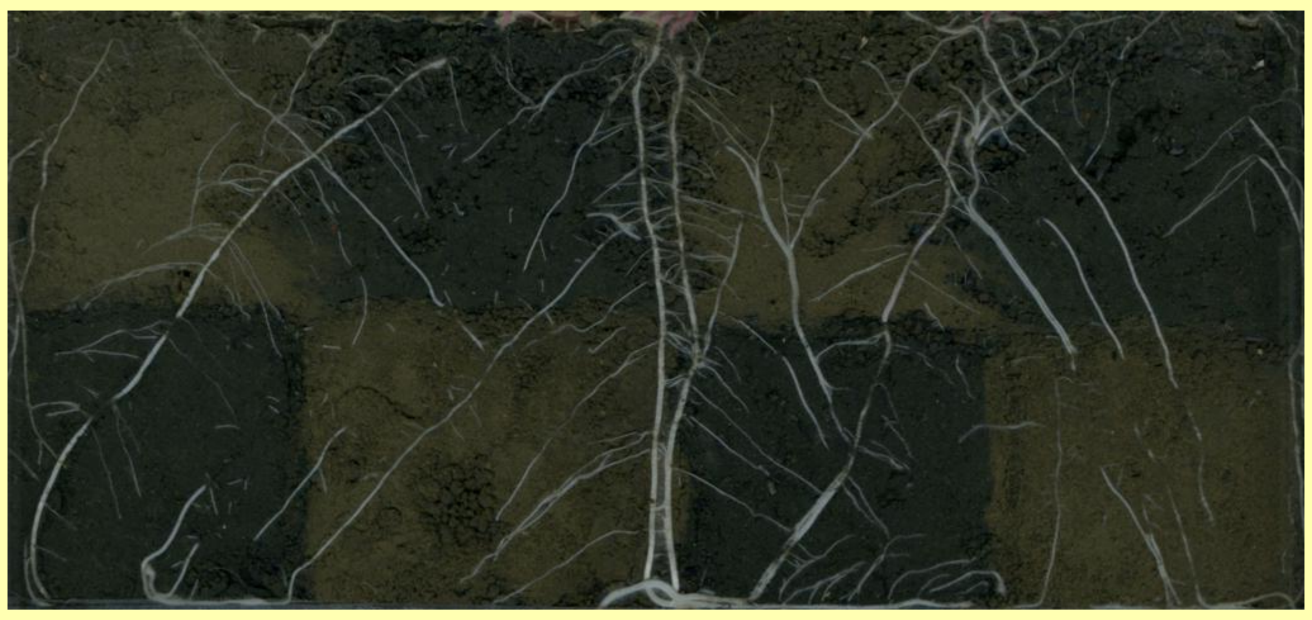
- After harvest (2 weeks for maize, 9 weeks for alpine pennycress):
→ Recovery of roots and measurement of root surface with Winrhizo software

RESULTS & DISCUSSION

DEVELOPMENT OF ZEA MAYS ROOTS



22	24	22	30
73	20	58	9



46	38	37	45
50	34	46	53

High-resolution pictures of soil profiles have been taken just after the harvest

ON SOIL A

- The zones with biochar have a **higher density of roots**
- Roots are generally moving towards the zones with biochar → **root tropism**

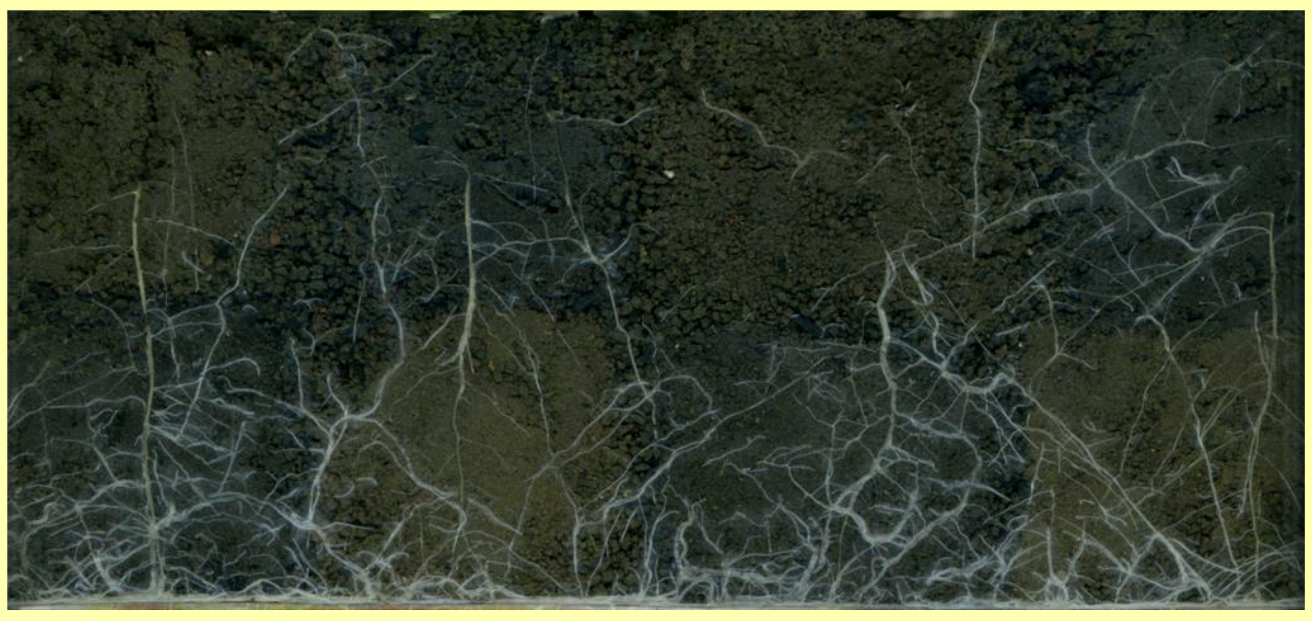
=> Biochar has **clear positive effects** on root development in a soil **with initial high metal availability and low pH**

ON SOIL B

- The zones with biochar do not have a higher density of roots
- No obvious trend of root tropism towards biochar can be observed

=> Biochar has **no significant effects** on root development in a soil with **initial low metal availability and high pH**

DEVELOPMENT OF ALPINE PENNYCRESS ROOTS



16	42	25	51
174	71	141	79

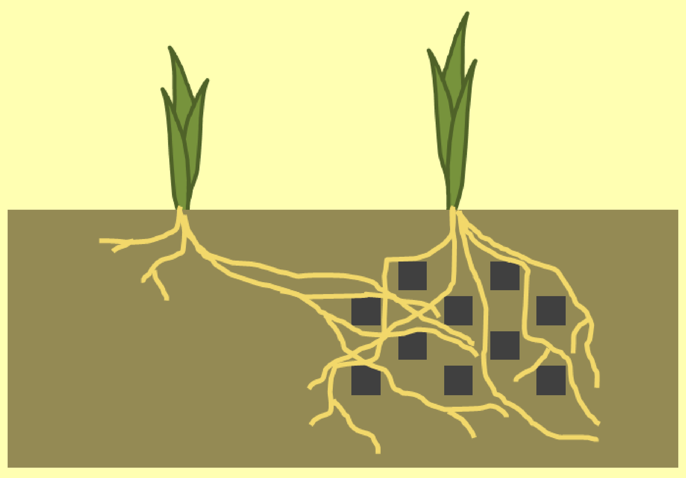
10	11	11	18
29	19	23	29

Tables represent the total root surface for the 8 squares of each soil profile (in cm^2)

CONCLUSIONS

- Considering that both soils have similar properties except pH, the **better root development with biochar** only observed on Soil A may be mainly **due to the decrease of soil metal availability.**

➔ Modifications of root development only occurs when biochar has a significant effect on chemical soil properties.



PERSPECTIVES

- Positive tropism of roots towards biochar could be an option to reduce the quantity of biochar and the work for biochar amendment.
- The consequences of a better root development on plant metal uptake and long term growth need further investigations.

[1]Prendergast-Miller, M.T., Duvall, M., Sohi, S.P. 2013. Biochar-root interactions are mediated by biochar nutrient content and impacts on soil nutrient availability. European Journal of Soil Science.

[2] Jones et al. 2012. Biochar-mediated changes in soil quality and plant growth in a three year field trial. Soil Biology and Biochemistry.

[3] Spokas, K.A., Baker, J.M. and Reicosky, D.C. 2010. Ethylene: potential key for biochar amendment impacts. Plant and Soil.

[4] Rees et al. 2014. Short-term effects of biochar on soil heavy metal mobility are controlled by intra-particle diffusion and soil pH increase. European Journal of Soil Science.

This work belongs to the research program LORVER and has been funded by Lorraine Region and FEDER program.

WCSS 2014