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

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ROOT DEVELOPMENT IN METAL CONTAMINATED SOILS AMENDED WITH BIOCHAR

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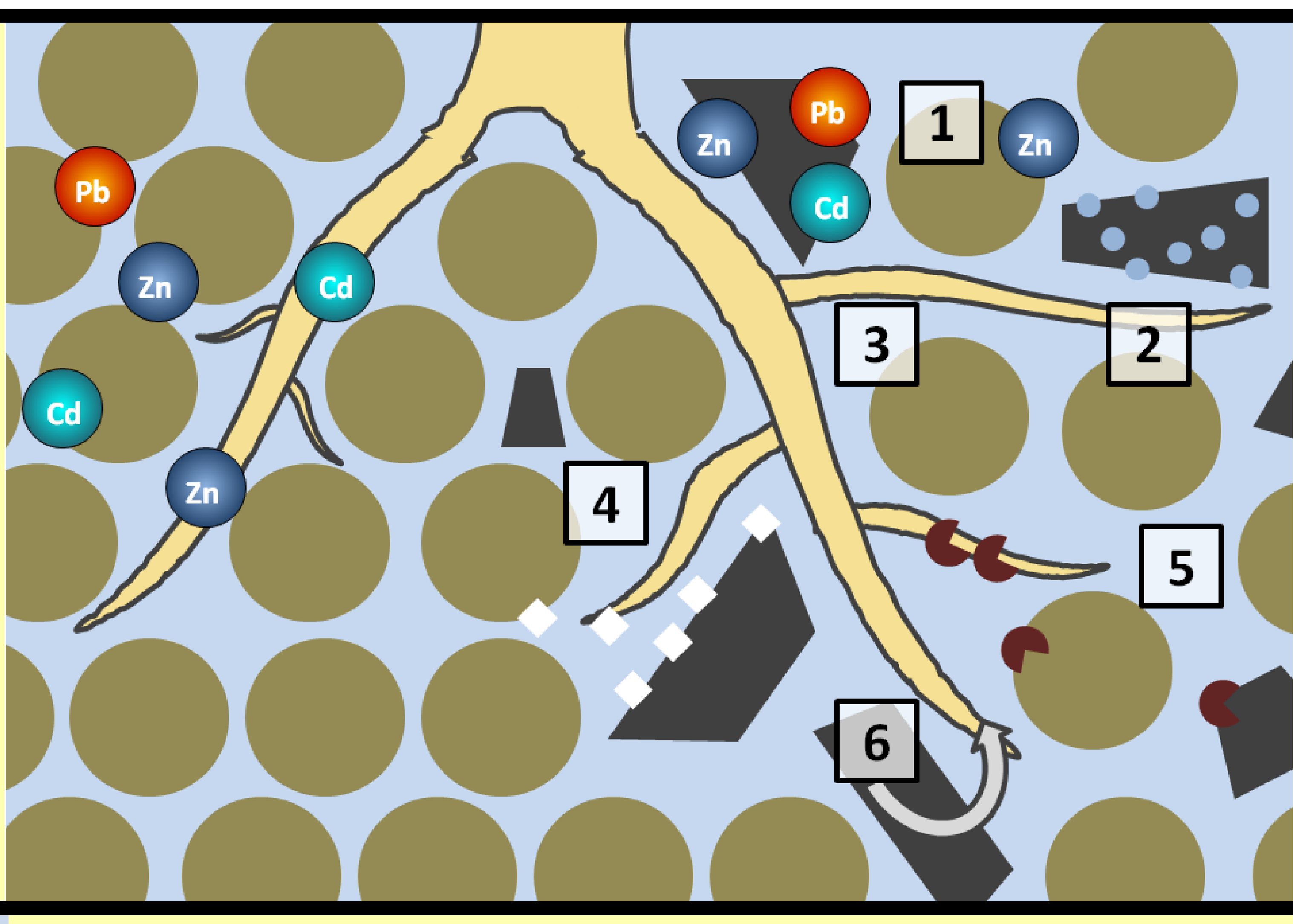
INTRODUCTION

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

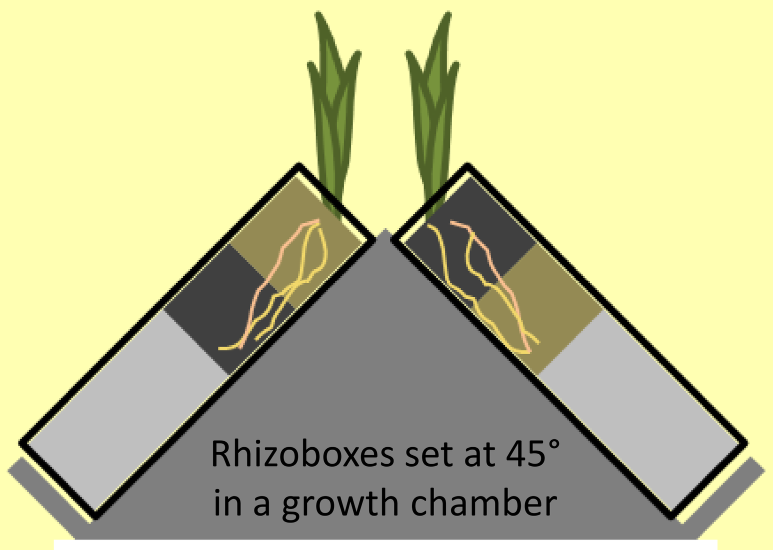
- **1 biochar** produced by Carbon Terra at ~450°C from woody biomass, <2mm, untreated (pH 9.2)
- **2 soils** contaminated with Cd, Zn, Pb, sampled near smelters, with similar properties but different pH.

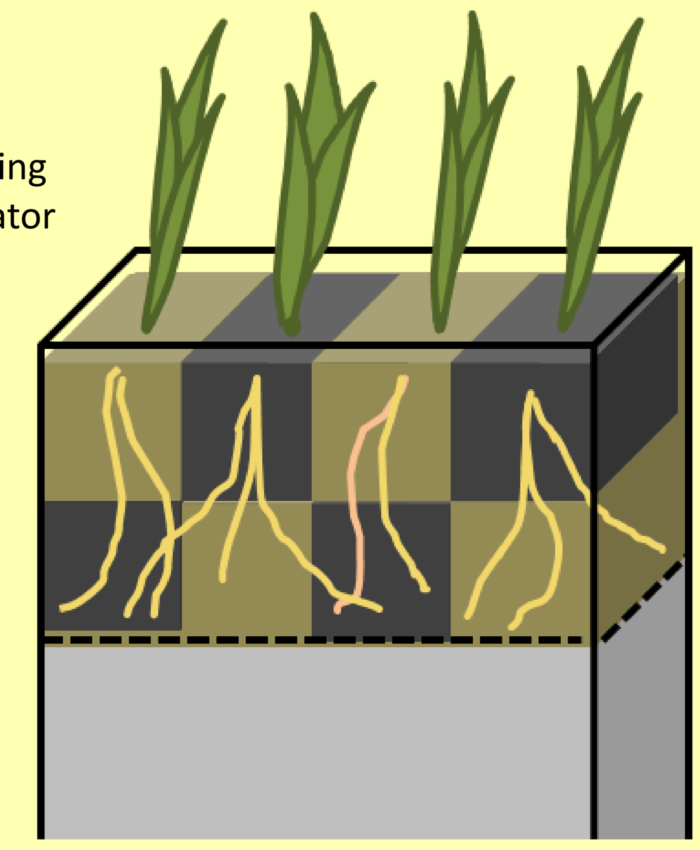
pH value and available (/ total) metals of soils (mg kg^{-1})

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**:

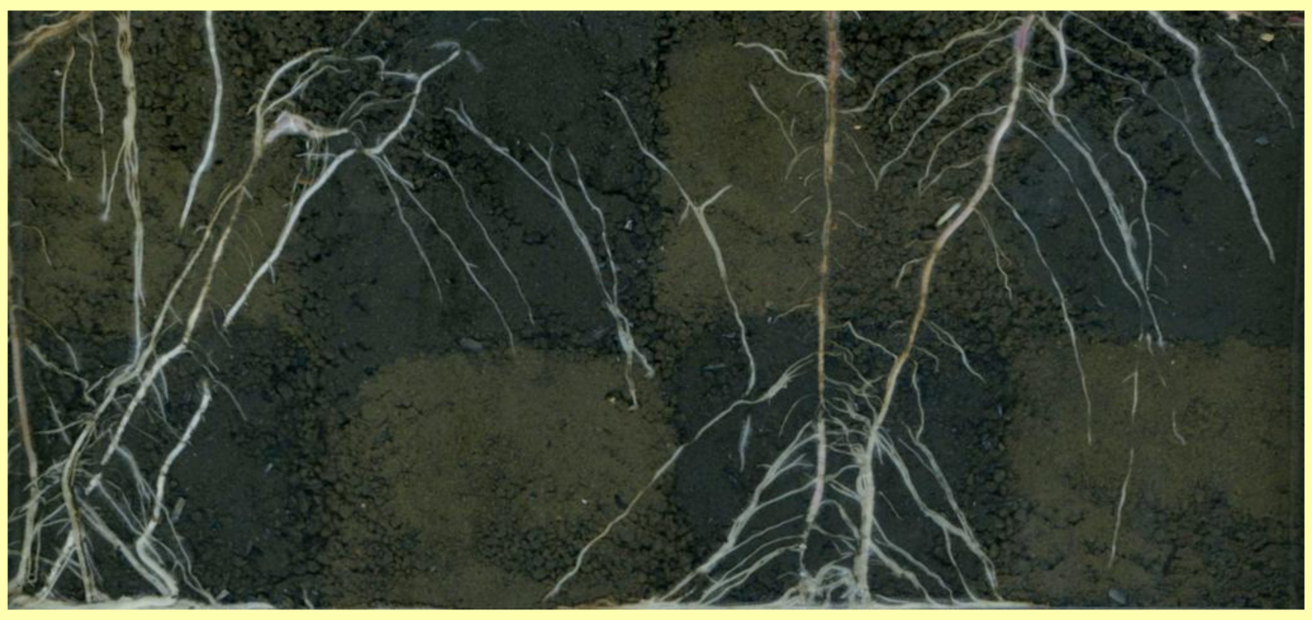
4 squares with pure soil
4 squares with soil + 5% (w/w) biochar

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

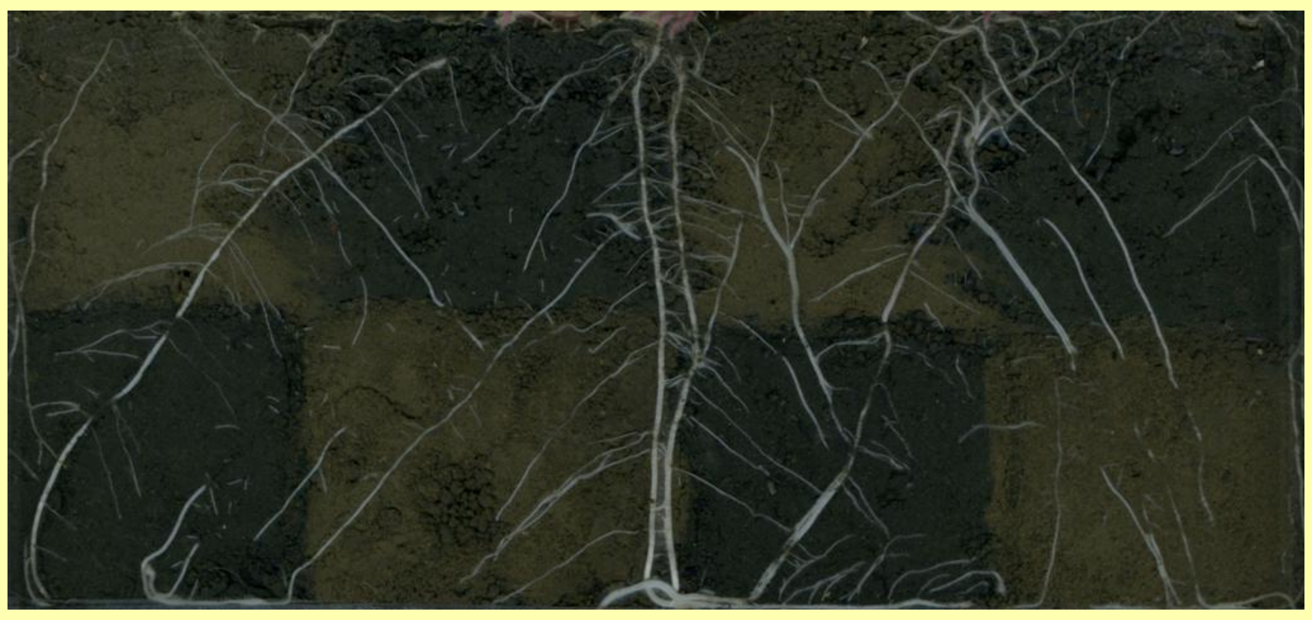
- After harvest (2 weeks for maize, 9 weeks for alpine pennycress):
→ Recovery of roots and measurement of root surface with Winrhizo software

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**

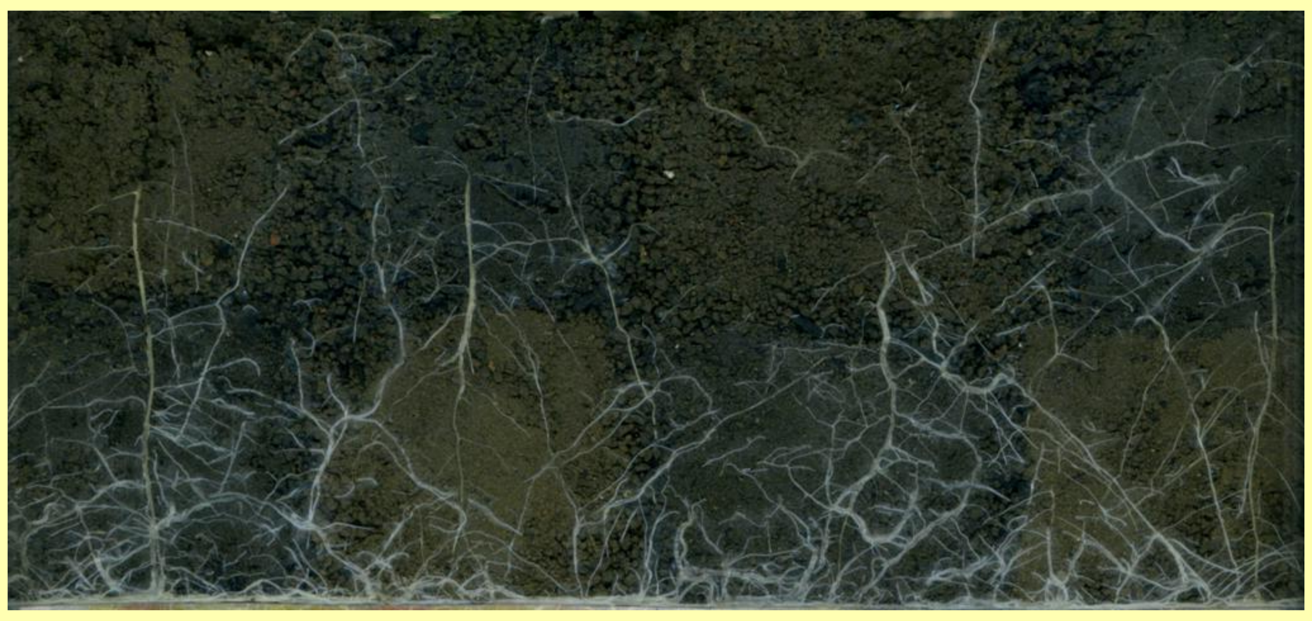
=> Biochar has **clear positive effects** on root development in a soil **with initial high metal availability and low pH**

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

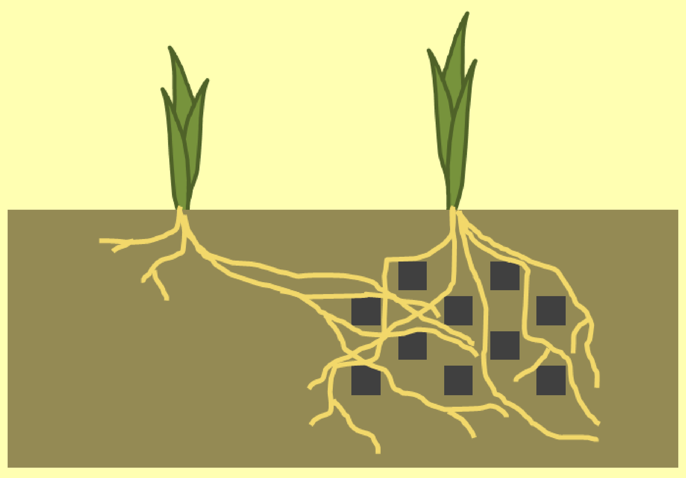
10	11	11	18
29	19	23	29

Tables represent the total root surface for the 8 squares of each soil profile (in cm²)

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.

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[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.

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