

PLANT-FUNGI ASSOCIATION: TRACK TO DIG FOR SUSTAINABLE AGRICULTURE; BEWARE OF METAL POLLUTIONS IN URBAN AREAS.

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Introduction

Soil, air and water quality in urban environments are becoming a major concern as pollution rates have been increasing since the industrial revolution. The European Environmental Agency considers that about 250 000 sites need remediation with around 100 000 ha contaminated by persistent metal(loid)s (M). The actual worldwide economic crisis pushed many citizens to pursue a will of self-growing food (Galt et al., 2014). But, the central question of food quality in terms of M amounts in vegetables. As sustainable gardening practices, gardeners can currently use biofertilizers (bacteria and/or symbiotic fungi) and organic matter amendments to increase plant yield (Kangwankraiphaisan et al., 2013). Organic matter (OM) addition and arbuscular mycorrhizal fungi (AMF) are however known to participate in M geochemical cycles through increased bonding to soil particles but also increased solubilization depending not only on soil physicochemical properties but also on plant and microorganism species (Foucault et al., 2013; Jarrah 2014). Vegetables such as lettuce (*Lactuca sativa* L.) and leek (*Allium porrum* L.) are widely cultivated in urban gardens; but as leafy vegetables, they present a great contamination potential. Cadmium (Cd) and lead (Pb) are common pollutants within urban areas and some data already exist concerning their relationship with AMF and OM (Jarrah et al., 2014) but knowledge is still scattered. Antimony (Sb) is an emerging anthropic contaminant (Krachler et al., 2005) and barely nothing is known about the role of AMF on its phytoaccumulation (Pierart et al., 2015). Hence, our research project, which is part of a national program for urban gardens (JASSUR), focused on contaminated soils coming from gardens which M content was either due to anthropogenic activities or to the weathering of the mother rock. We studied the role of AMF symbiosis and OM addition (lombri-compost) on the transfer of Cd, Pb and Sb from soil to lettuce and leek depending on the contamination origin. Finally, human health risk was estimated through M human gastric bioaccessibility (Xiong et al., 2016).

Methods

A greenhouse pot experiment has been set up as follows: plants were subject to geogenic (NTE) and anthropogenic (BZC) M sources at similar Pb concentration (~450 ppm) but different Sb and Cd concentrations (~3 vs 15 ppm_{Sb} and 2 vs 0.5 ppm_{Cd}). For each soil, a crop rotation was carried out as described in Figure 1. Organic leek was used to multiply the natural AMF inoculum from contaminated soils: Leeks were grown under the same greenhouse conditions in pots filled with a mix of NTE, BZC and sterilized oildri (1:1:6 v:v:v). Spore extraction was performed to prepare a spore suspension (280 sp/ml) used for bioaugmentation. After each harvest, plants and soils were analyzed to compare M accumulation in edible parts (phytoaccumulation). The human bioaccessible fractions for the various plant samples were measured using the adapted Unified Barge Method (UBM, Denys et al., 2012). In the following study, bioaccessibility refers specifically to human bioaccessibility.

Results

1. Depending on soil characteristics, plant Pb and Cd accumulation varied:

Focusing on soil residual contamination after the two cultivations, a difference of phytoextraction is observed for Pb and Cd (all modalities gathered). On BZC soil, leek represents about $\frac{3}{4}$ of soil Pb and Cd loss, while in NTE soil, it only represents $\frac{1}{3}$ of Pb loss (and $\sim 50\%$ of Cd loss). In the case of Sb, the soil type does not seem to affect its transfer to plant: in both cases, leek participated in $\sim 75\%$ of Sb soil loss.

2. Influence of AMF bioaugmentation and OM addition:

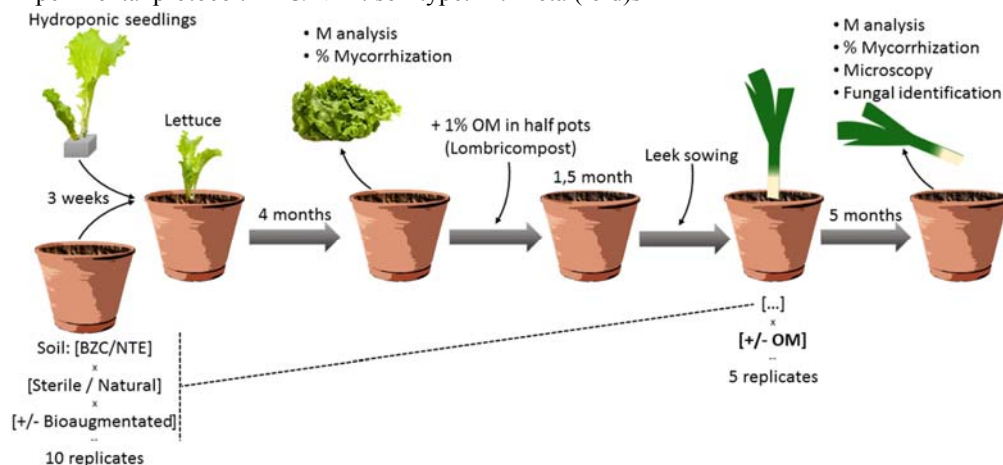
Lettuce: On NTE soil, bioaugmentation lead to a decrease of total Pb and bioaccessible Sb in roots, similar results were obtained on BZC soil. However, for Cd, bioaccessibility on root increased in that case.

Leek: Bioaccessible Sb in root is increased by bioaugmentation on geogenic soil; OM addition decreased Pb phytoavailable fraction (which could eventually be uptaken by plant); but it increased Sb.

Conclusion

In the case of Cd, Pb or Sb contamination, the use of OM and biofertilizers such as AMF in our conditions led to complex effects, probably due to thin interactions and multiple effects between ecotoxicology, plant metabolism, soil properties and element competition. For now, a combined effect of AMF and OM seems to decrease Pb and Sb in leek leaves on BZC soil. However, results are showing good tendencies on NTE soil. Thus, further investigation is needed to enhance hazard recommendations for gardeners.

Figure 1. Experimental protocol. BZC/NTE: soil type. M: Metal(loid)s



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