Phosphorus vs. Mycorrhiza: Mitigation of Lead Uptake in Tomatoes

Helen Senerchia,[1] Liz Miernicki,[2] and Andrew Margenot[2]
Community College of Philadelphia, Philadelphia, PA[1]
Department of Crop Sciences, College of ACES, University of Illinois at Urbana-Champaign[2]

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Introduction

- Urban agriculture is often practiced in soils with heavy metal contamination
- Growers apply phosphorus (P) to contaminated soils to reduce the bioavailability of lead (Pb)
- Natural mutualism relationships between arbuscular mycorrhizal fungi (AM) and roots of food plants reduce plant uptake of heavy metals[1], but applications of P can discourage formation of these relationships[2]
- A better understanding of these interactions is necessary to determine which management practices are most beneficial to soil microbiome, plant, and human health

Project Goal

This study seeks to understand how the mutualist relationship between AM and *Solanum lycopersicum* (tomato) affects the uptake and distribution of soil Pb by tomatoes and how P application affects may pose a trade-off between AM and P mitigation of bioavailability of Pb.

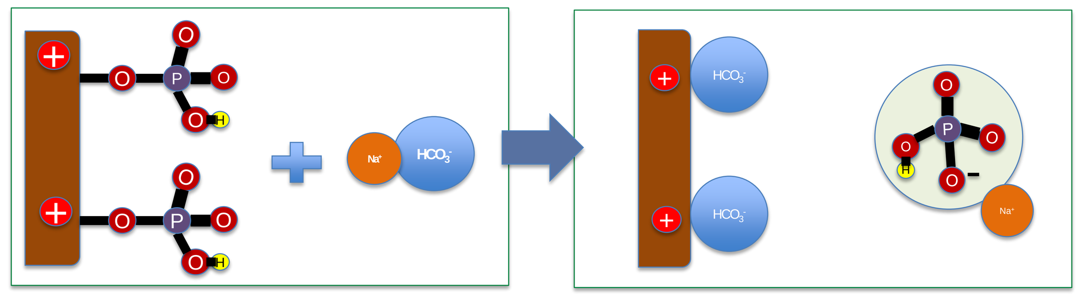
Determining Pb & nutrients in soils

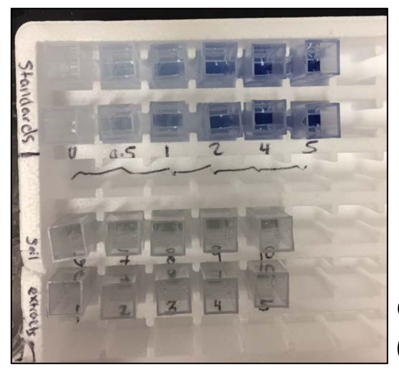
Portable X-Ray Fluorescence (pXRF)

pXRF is a technique which utilizes a handheld instrument to analyze elemental composition of materials[3], enables assessment of Pb and nutrient content of soils on-site. pXRF is used at field sites and on harvested soil.

Olsen Test for Available P

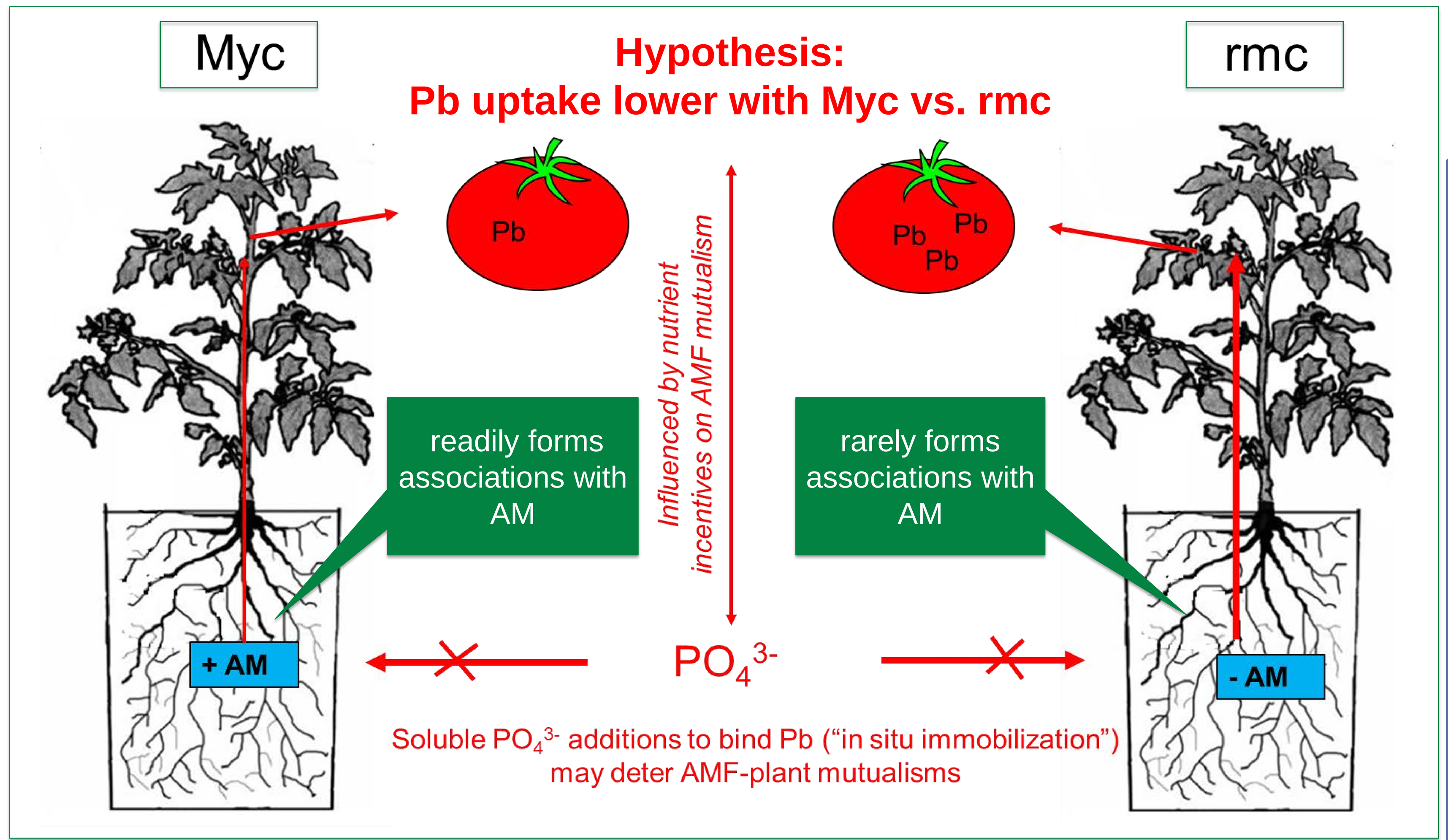
The Olsen test is useful for determining the amount of available inorganic P in soils that have a neutral to high pH[4].



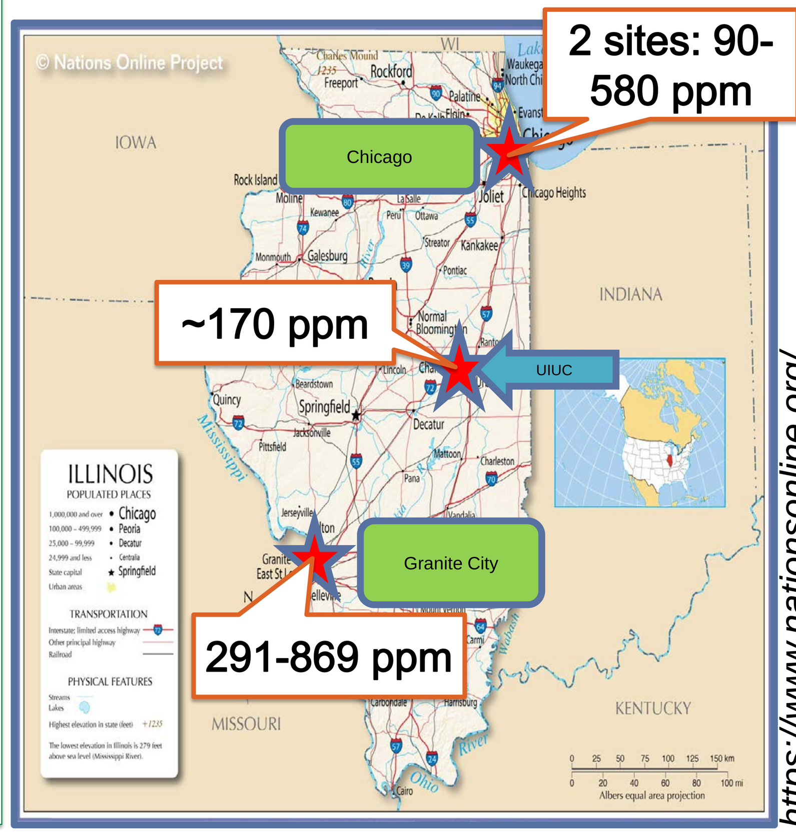


When the phosphate ions complex with molybdate in the Murphy-Riley reagent used in the test, they turn blue, enabling colorimetric analysis at wavelength of 882 nm.

Cuvettes of standard solutions (top) and soil extractions (bottom)



The Research



https://www.nationsonline.org/

Field sites

Examines AM mutualism's effect on tomato Pb uptake in complex environments

Photo credit: Treasureworks

pXRF testing determines presence of Pb gradients & necessity of soil amendment

10-12 replicates per genotype, randomized across plots and/or blocks, are planted at 4-6 weeks old

Randomized plot of Myc & rmc in Granite City

Visits are made to the sites to mulch, weed, and observe plant health indicators: height, insect damage, disease

Greenhouse study

Examines effects of P application on AM-tomato relationship, tomato Pb uptake, and soil Pb mobility

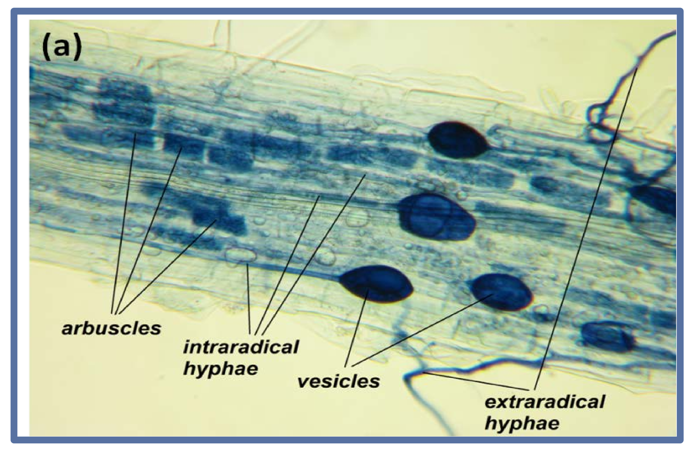
Soil harvested from Chicago site is processed and tested to determine rates of P application for fertilization and Pb mitigation

60 seedlings in pots are placed in randomized blocks with uniform Pb level

Mass of pots is recorded daily, and water added to return pots to 25-30% WHC

Randomized blocks of Myc & rmc in the IUIC

Level of Treatment	P application rate
Control: from Olsen P, 13.8 ppm P already present in soil	None
Agronomic: >25 ppm Encourages healthy plants	+13.8 ppm P as KH_2PO_4 (P ppm*kg soil)/(g/mol P*m.w. KH_2PO_4)
Mitigation: 0.1% of soil mass Sequesters Pb in soil	+P at 0.1% of soil mass as KH_2PO_4 5.5g P(1mol P/30.97g)(136.06g/1 mol KH_2PO_4)



Determining AM colonization of roots

Plants are watered and monitored until harvest at fruiting. Roots are cleaned, and cleared of their natural pigment, then stained with a solution of trypan blue to make hyphae, vesicles, and arbuscles of AM in roots visible under a microscope[3].

Biomass fractions are examined for concentration of Pb to determine effects of colonization.

http://web.biologie.uni-bielefeld.de/systemoekologie/index.php/de/research-projects/mycorrhiza

Current Challenges

Setbacks caused by fusarium wilt and multiple viruses can be avoided in the future by replicating the experiment in a greenhouse treated with trisodium phosphate (TSP) and free of any other plants, and using soil sterilized and reinoculated with its native AM[5].

Anticipated Results

Analysis of biomass fractions from field sites will illustrate the efficacy of AM as a protective measure against Pb uptake in food crops. Greenhouse data can be expected to indicate whether P application for in situ immobilization of Pb affects AM-tomato relationships.

Future Work

- Similar studies are necessary to investigate efficacy of these mitigation strategies in other food crops
- Individual AM adapt to environmental stressors. Species isolated from stressful environments may improve plant survival and yield in inhospitable conditions[6]
- Differing environments require study, since complex interactions between soil, soil microbes, fungi, and plants affect treatment outcomes
- Additional mitigation strategies can be explored to provide options that suit various environments and economies

References

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http://precs.igb.illinois.edu/

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