Influence of Biochar Application on Per- and Polyfluoroalkyl Substances (PFAS) in Two Vegetable Crops: A Paired Field and Greenhouse Study

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ABSTRACT

Per- and poly-fluoroalkyl substances (PFAS) are a group of man-made chemicals and highly strong organic compounds (with multiple C-F bonds) found to be widely dispersed throughout the environment via anthropogenic activities; the application of biosolids in the farmland of Maine being a major problem. The use of climate-smart input biochar has shown some promising results in environmental mitigation, such as, sorption of heavy metals and PFAS from water samples, besides its well-known agronomical benefits. Thus, this study aimed to assess the role of biochar in PFAS sorption from soils and the reduction of PFAS uptake by crops. This study was conducted to observe the effects of dilution and adsorption of PFAS on PFAS-contaminated soil by adding biochar, PFAS-free soil, or compost in either of setup- greenhouse and field experiment. Also, this study focuses on understanding the influence of environmental factors on the accumulation of PFAS in edible plant parts like fruits in tomatoes, and leaves in lettuce under greenhouse and field conditions. We are also recording physiological traits of plants like stomatal conductance, and chlorophyll content to see if there is any association between stomatal opening and closure with PFAS uptake by plants in varied dilution effects.

INTRODUCTION

- PFAS are a group of man-made chemicals, persistent in nature (with multiple C-F bonds)
- PFAS are found in numerous commercial products, from coatings in non-stick pans to food wrappers, fire-fighting foams, and agrochemicals.
- The movement of PFAS in soils/leachate can be fulfilled by stabilization of PFAS via sorbents (i.e., binding agents), e.g. Biochar/Activated carbon/Modified clay.
- Biochar derived from woody biomass might be used as a cost-effective sorbent for PFAS if its performance could be fully investigated.

GOALS AND OBJECTIVES

- To quantify the amount of PFAS uptake by leaves in lettuce and in fruits in tomato in three soil types in a greenhouse and field study
- To study the PFAS movement in soil leachate in three soil types under greenhouse conditions

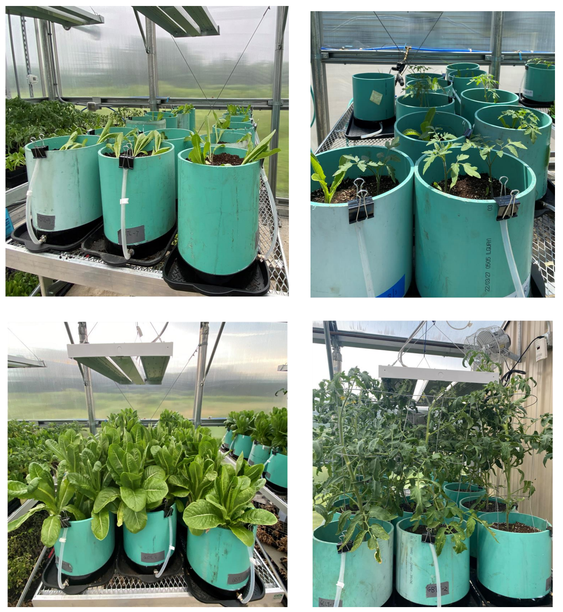

Figure 1: Lettuce (left) and tomato (right) in three soil treatments (Greenhouse observations)

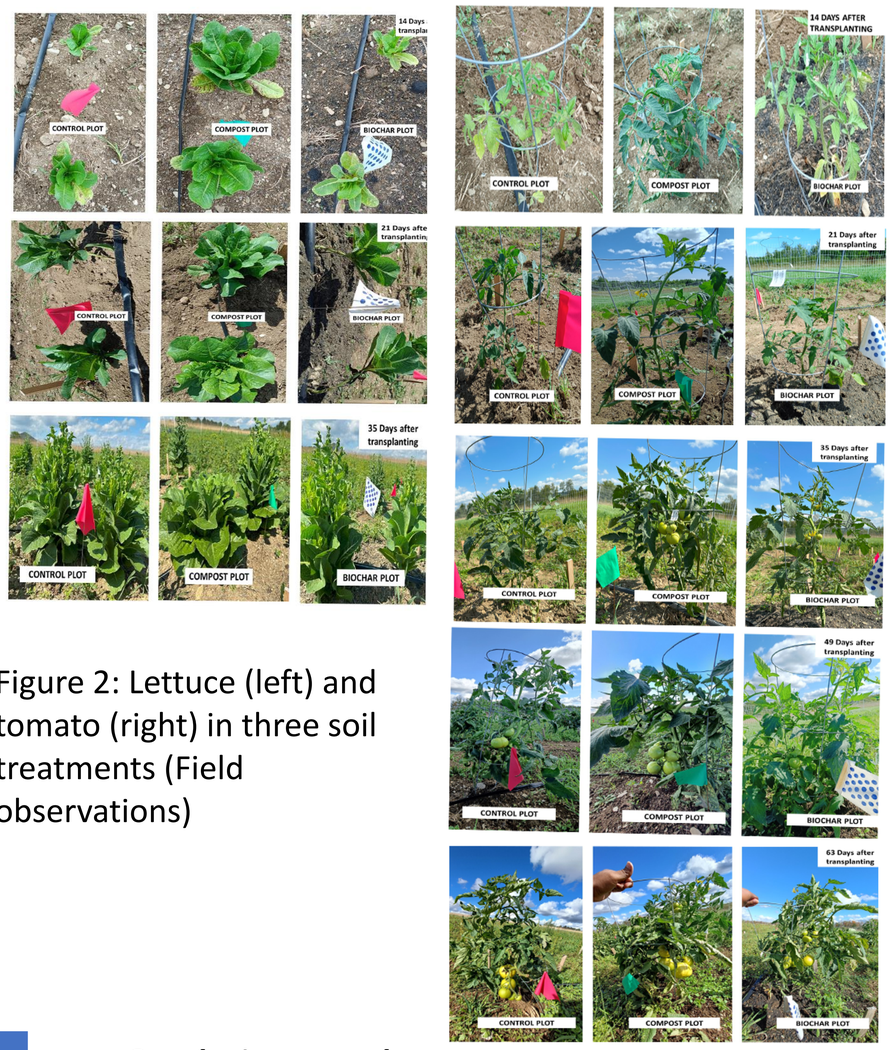

Figure 2: Lettuce (left) and tomato (right) in three soil treatments (Field observations)

MATERIALS AND METHODS

- **Crops: Tomato (*Solanum lycopersicum* L. and lettuce (*Lactuca sativa* L.)**
- **PFAS spiking:** Spiking was done for the greenhouse only with 220ppb each of PFOA, PFOS, PFBA, and PFBS respectively which was completed 1 week prior to transplanting.

Table 1. Experimental Design

Factors	Greenhouse (UMaine)	Field (Unity, Maine)
Method of design	Completely Randomized Design (CRD)	Completely Randomized Block Design (RCBD)
Seeding & transplanting	Seeding was done on 19th May 2023 and Transplanting on 20th June 2023	Seeding was done on 19th may 2023 and transplanting on 28th July 2023
Treatments	Control (n=6), Soil treatment (n=7), Biochar (n=7)	Control (n=10), Soil treatment (n=10), Biochar (n=10)
Watering	Daily	Twice a week
Plant management	Weekly (staking, pot rotation, and pruning of tomatoes)	Biweekly (weeding, fertilization and pruning of tomatoes)
Plant growth traits	Biweekly (pots rotating)	Biweekly
PFAS quantification	Soil, leachate(water through drainage hose), leaves(lettuce), fruit (tomato)	Soil, leaves(lettuce), fruit (tomato)

Conclusive remarks:

- The growing season was completed on Oct 14, 2023
- All samples were collected and are being tested in the third-party lab.
- This paired study will help to compare the trend of PFAS movement in soil, water, and uptake by crops under varying environmental conditions.

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