Phytotoxicity and fungitoxicity of biochar-amended substrates: implications for seedling development and disease suppression

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Introduction

Biochar has emerged as a promising soil amendment capable of improving physical and chemical soil properties, enhancing water retention, and promoting microbial diversity—all while contributing to a more sustainable, circular bioeconomy. However, despite these well-documented benefits, key uncertainties remain regarding the potential phytotoxic effects of biochar on plant development and the influence of biochar aging within terrestrial ecosystems. This study, conducted within the framework of the SOLVO project, aims to 1) evaluate the effects of biochar-amended substrates on seedling development and potential phytotoxic responses, and 2) assess the fungitoxic and disease-suppressive properties of biochar against key fungal pathogens.

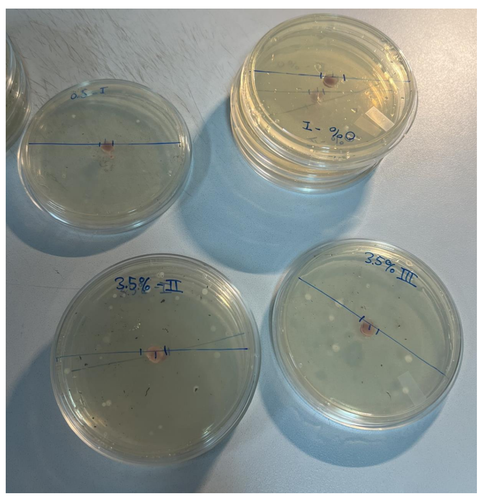
Materials and methods

- Phytotoxicity tests were conducted using Lactuca sativa L. seeds incubated in darkness at 25 °C for 72 h.
- Soil–biochar mixtures were prepared with biochar concentrations ranging from 1% to 100%. The soil used for these mixtures is SIRO substrate.
- Tests were performed both at the start and after a three-month pot experiment developed within the scope of the project to evaluate the effects of biochar aging.

Petri dishes with Lactuca sativa L. seeds on soil with different biochar concentrations in the incubator

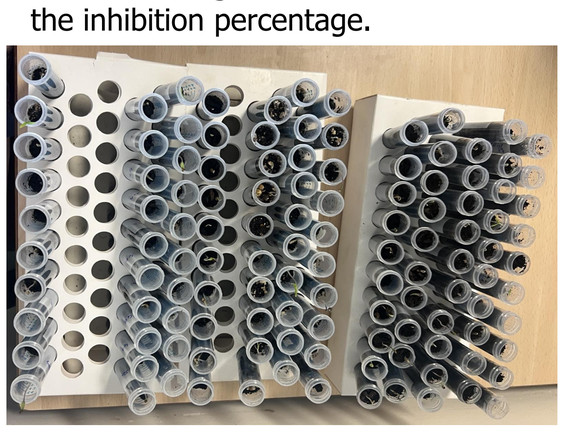
Lactuca sativa L. seeds after being incubated in darkness at 25 °C for 72 h

Olive trees in three-month pot experiment



Petri dishes with PDA medium, biochar concentrations between 0.5% and 5% tested against C. accutatum

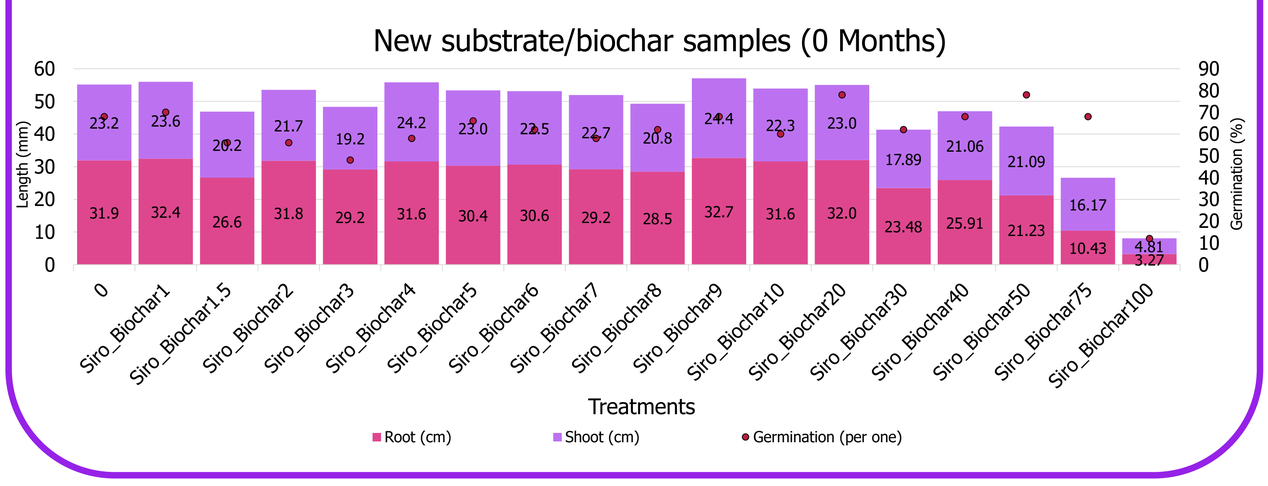
- Fungitoxicity assays targeting anthracnose (*Colletotrichum accutatum*) were performed using tomato seeds, using the samples after a three-month pot experiment.
- In vitro, in Petri dishes with PDA medium, biochar concentrations between 0.5% and 5% were tested against C. accutatum, to determine the inhibition percentage.

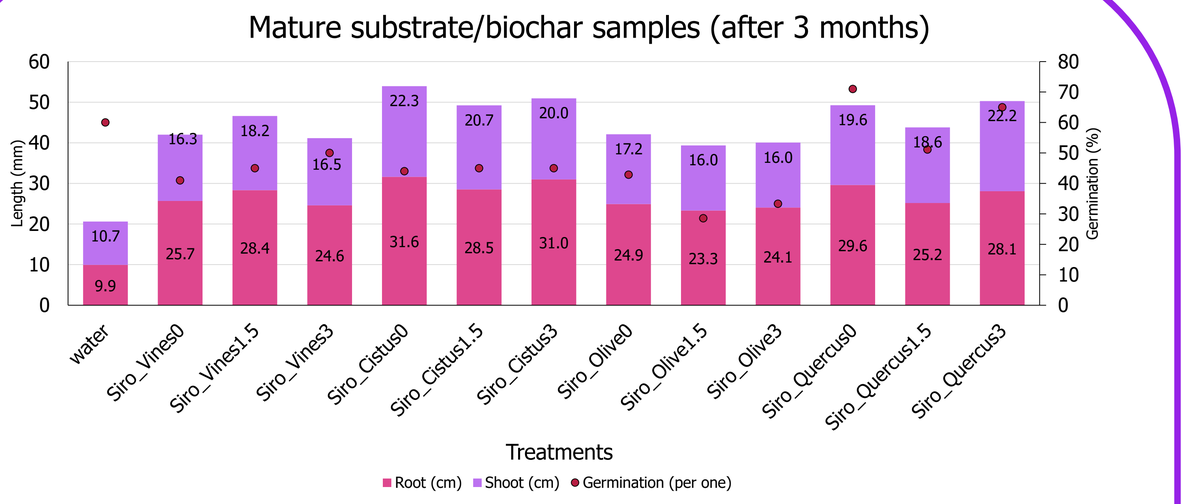


Fungitoxicity assays with tomato seeds and Colletotrichum accutatum

Results

- Concentrations of 50% Biochar and higher clearly diminish plant growth

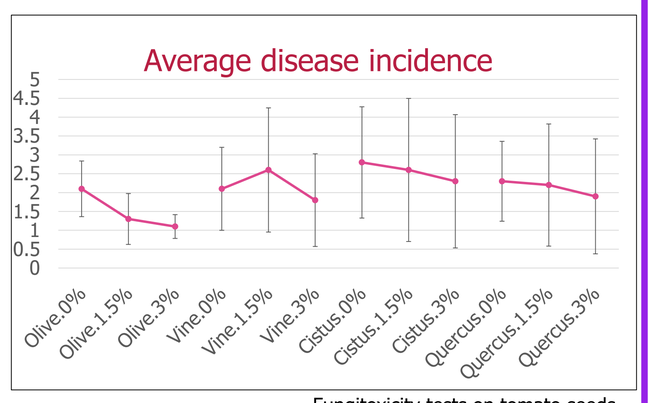




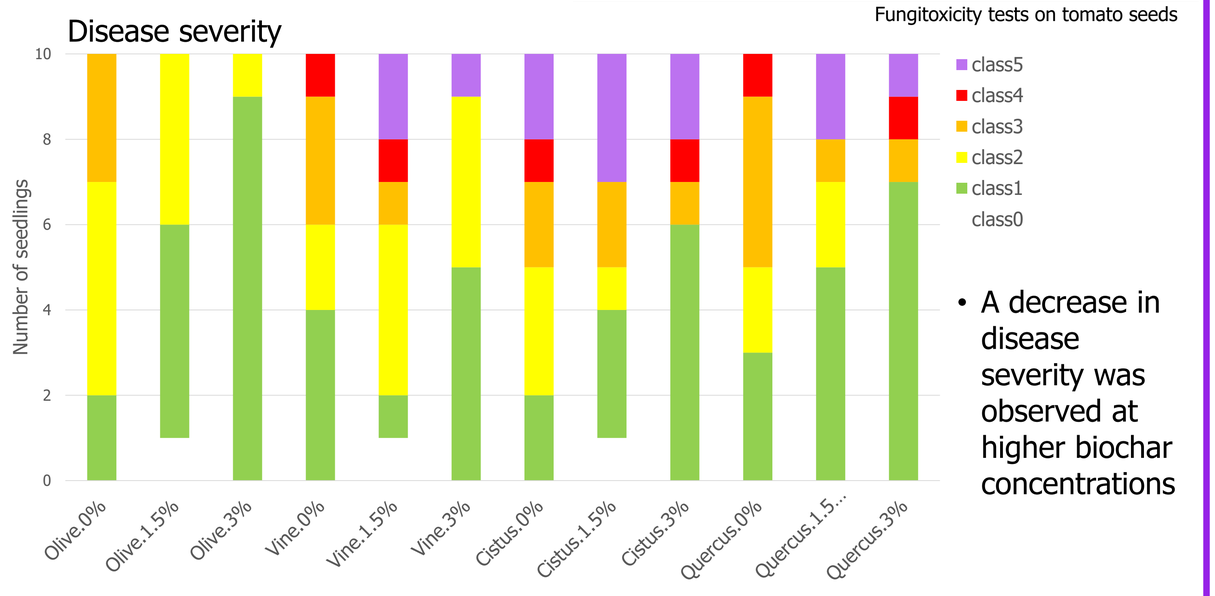
- Visible reduction in the incidence of C. accutatum with biochar

1	Healthy seedling
2	Minor symptoms at the root
3	The seedling breaks in the collar area
4	Sick, dying plant
5	Seed died

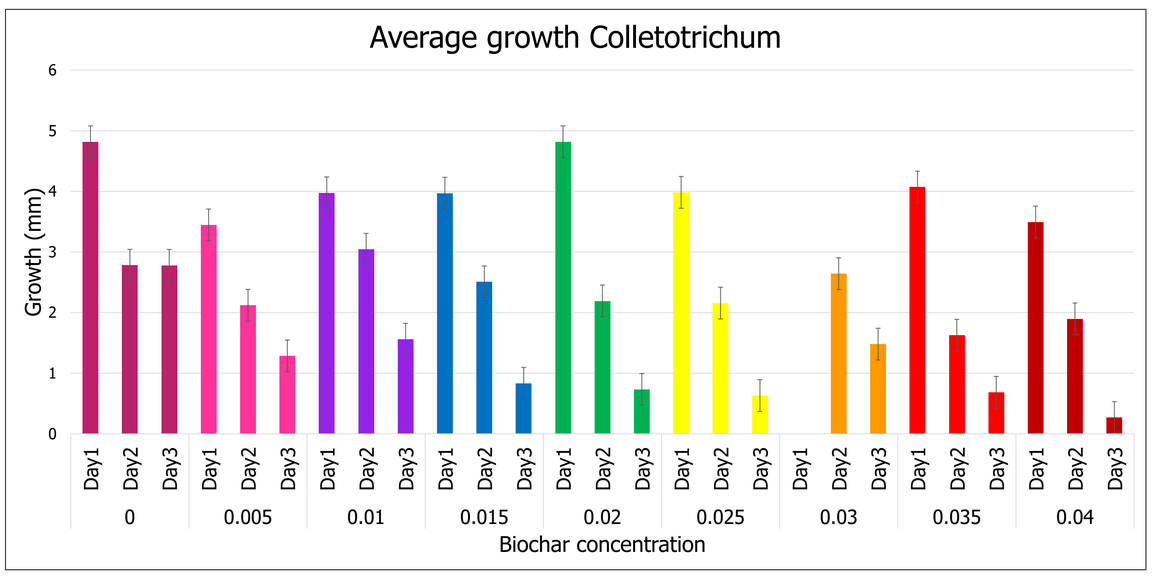
The healthy seedlings (left) and invested with disease (right). Level of disease are, from left to right: 1; 1; 1; 2; 3; 3; 4



Fungitoxicity tests on tomato seeds



- A decrease in disease severity was observed at higher biochar concentrations



- On average, the growth of C. accutatum decreased at increasing biochar concentrations.

Conclusions

- Results show that biochar concentrations between 1.5% and 10% promoted seed germination and seedling growth, while phytotoxic effects became clearly evident at concentrations of 20% or higher, marked by significant reductions in root and shoot elongation. Complete inhibition of germination occurred at concentrations of 50% and above.
- Biochar aging for three months did not significantly alter its physicochemical properties, apart from a slight decrease in pH, nor did it change its biological effects.
- For the fungitoxicity tests, anthracnose incidence was substantially reduced at biochar concentrations of 3–4%. Overall, biochar levels between 3% and 10% enhanced plant development and demonstrated strong anthracnose-suppressive activity.

ACKNOWLEDGEMENTS AND FUNDING

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