Amendment of poor soil substrate by Biochar saturated with biofertilizers (algae, manure) for sustainable production of relevant Palestinian and German crop plants (*Solanum lycopersicum L.* and *Hordeum vulgare L.)*

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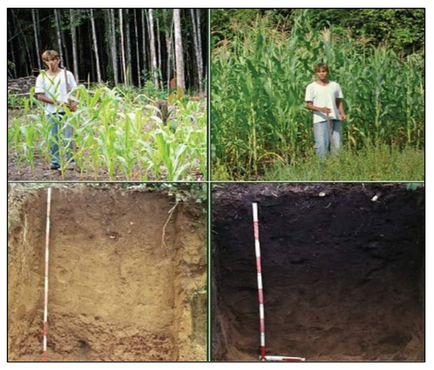
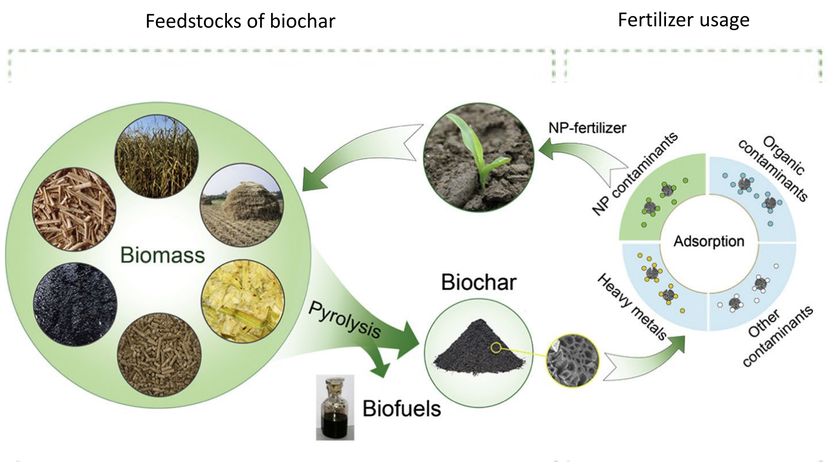
Introduction – biochar soil amendment

- Soil degradation: a global problem affecting many regions and communities, resulting in poor and stress-prone marginal soils.
- Biochar - charcoal derived from the pyrolysis process in the absence of Oxygen, can be saturated with nutrients and return C to substrate.
- Biochar as a soil conditioner can improve soil quality, e.g. structure, water holding capacity, and fertility, facilitating plant growth and quality especially in poor and saline environments.
- The main target of this work is to contribute to closing the nutrient cycle by biochar application to nutrient-poor soil, combining it with different organic biofertilizers, such as algae and manure.

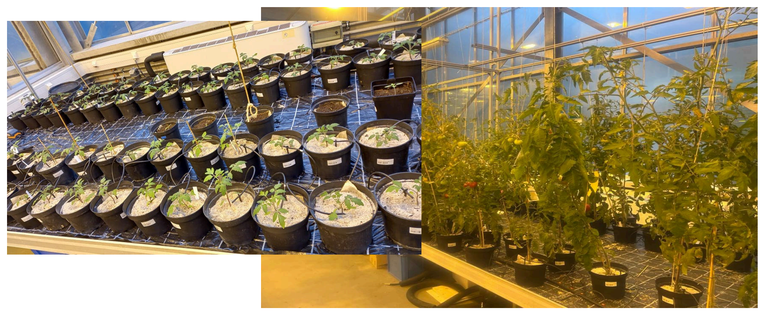


Historic example - discovery of biochar effects: "Terra Preta" in the Amazon region mixed with bio-remaining waste from human settlement (de Gisi et al., 2014)



Biochar + pig manure, + algae: effects on tomato plants and substrate

Biochar saturated with biofertilizers



Biochar effect on Palestinian Tomato cultivar early growth

- Biochar was saturated with algae & pig manure to 0.1%, 0.3% and 0.5% total C content, then applied to poor sandy and saline conditions (4 EC), investigating growth, fruit biochemical content and substrate improvement (e.g. WHC, remaining nutrients).

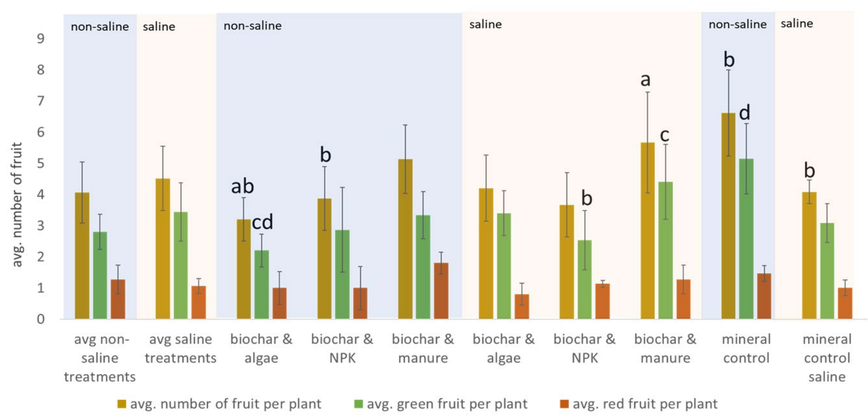
Biochar + sheep manure: effects on barley and substrate

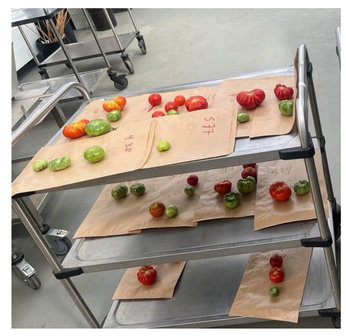
Biochar effect on Palestinian & German cultivars' seed germination stage

Biochar effect on Palestinian & German cultivars' early growth stage

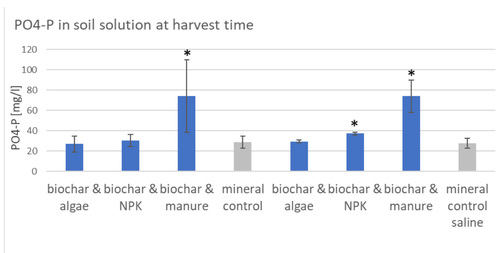
- Biochar was saturated with sheep manure to 0.5% and 2% total C content, then applied to nutrient-poor substrate (quartz sand with Speyer substrate 2.1 (3:1)) to investigate effects on plant growth and composition, and on substrate parameters like nutrient leaching and WHC.

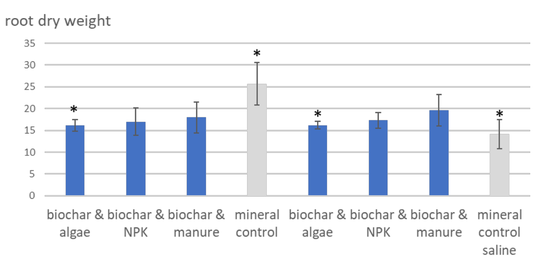
Exemplary results

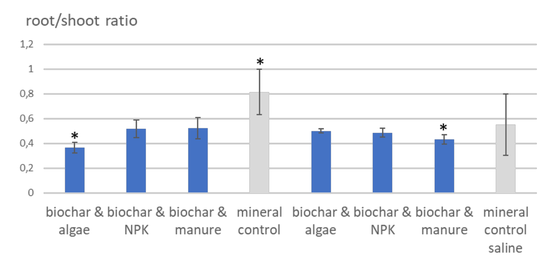




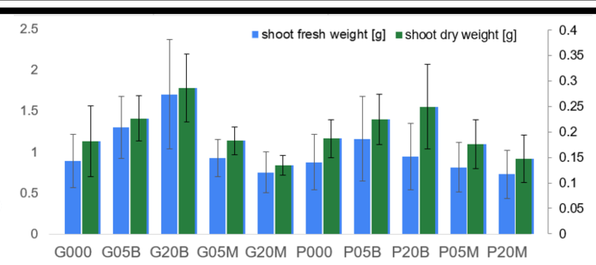
Mineral and organic fertilizer (Algae, manure) additvies on Palestinian tomato (*Solanum lycopersicum* L. 'Hebron'): effects on fruit number.
Statistics for green fruit (c,d): F(7,16)=3,15, p=.027; red fruit not significant; total fruit average (a,b): F(7,16)=3,20; p=.0,022 (p<0,05, one-way ANOVA, Tukey-Kramer post-hoc, only strong effects after Cohen's D >0.8 shown)







- Overall: biochar-manure pots ‚strongest performers', comparable to mineral control.
- Saline treatment has more green fruit and a higher green/red fruit ratio -> delayed ripening?
- Root dry weight is lower in all biochar treatments, reflected also in the shoot/root ratio.
- Higher amount of plant-available phosphate in solution in biochar manure treatment.



Biochar saturated with sheep manure & Hoagland solution: effect on Palestinian & German cultivars' early growth stage.

- shoot dry weight is highest for biochar-mineral treatment and lowest for biochar-manure treatments.
- Increased biochar amount (up to 2%) increased shoot fresh weight in the German barley cultivar after a 1-month growth period, compared to non-treated (0% biochar) pots.

Remarks & Critical questions

- Tomato root DW and root/shoot ratio decreased in all biochar treatments; were roots not needed or was growth hampered?
- With a view to nutrient efficiency and effects on product quality (e.g. grain protein content, antioxidants); is high quality achievable with less input, as the first results suggest? Is this economically applicable on poor substrates?

Next Steps

- A scaled-up experiment is now in progress (biochar-, lignite-, and mineral- based additions in agriculture-relevant formulations

Conclusion

- Further analytics on effects of biochar treatments on greenhouse- and larger scale necessary: e.g. 'crop garden bins' (250l, less root limitation, outdoors, several treatments/biochar levels possible); field experiments
- In Tomato pot substrate, the overall phosphorus levels were relatively similar (not shown); the P availability may therefore depend on the different mixtures, this needs more investigation; similarly for N.
- The addition of pig or horse manure instead of sheep manure could have a better effect on plant growth because they are not ruminant animals (higher nutrient content compared with sheep manure).

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