Enhancing soil quality and carbon sequestration through biochar soil amendments

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What is biochar?

Biochar is produced by pyrolysis, which is the thermal decomposition of organic materials (e.g. wood, nut shells, poultry litter) at high temperatures (> 400 ^oC) in the absence of oxygen. During the pyrolysis process, depending upon temperature, heat is also generated, which can be used to produce electricity, along with bio-oils that can be used as a fuel for tractors and other farm equipment. Biochar is therefore, not only a potential large and long-term sink of carbon when added to soils, but also reduces the CO_2 emissions associated with fossil fuel consumption.

How can it improve soil quality and enhance carbon sequestration? What are the benefits?

- Adding biochar to soil has the potential to sequester atmospheric carbon into soils by locking biomass carbon into the soil.
- Biochar added to soil can improve soil nutrient retention and improve nutrient availability to plants due to its high cation exchange capacity.
- Improvements to nutrient retention and remediation of soils can increase crop yields.
- Therefore, biochar can improve soil fertility and production capacity while maintaining high levels of soil C.
- Soils amended with high C:N plant materials generally have a greater incidence of fungal feeding nematodes, therefore the addition of biochar with high C:N ratio to soil could lead to a shift in decomposition to a more fungal based channel. Therefore, biochar has the potential to promote a more intact, healthy soil food web with more effective nutrient cycling, which in turn can result in a reduction in GHG emissions.

Our research

We are currently evaluating whether the addition of a high temperature (pyrolyzed at 950^oC) walnut shell derived biochar has the ability to improve soil quality and soil biodiversity while simultaneously reducing greenhouse gas emissions (e.g. N_2O, CO_2) and improve crop yield.

Results

1. **Soil quality changes and lettuce yield**

The impact of biochar soil amendments resulted in an increase in soil C resulting in a higher C:N ratio. Furthermore biochar amended soils had a significantly ($P = 0.014$) greater retention of potassium compared to control at the end of a 1 year experiment in a lettuce cropping system. Lettuce yield was neither significantly positively nor negatively impacted following the addition of biochar to the soil.

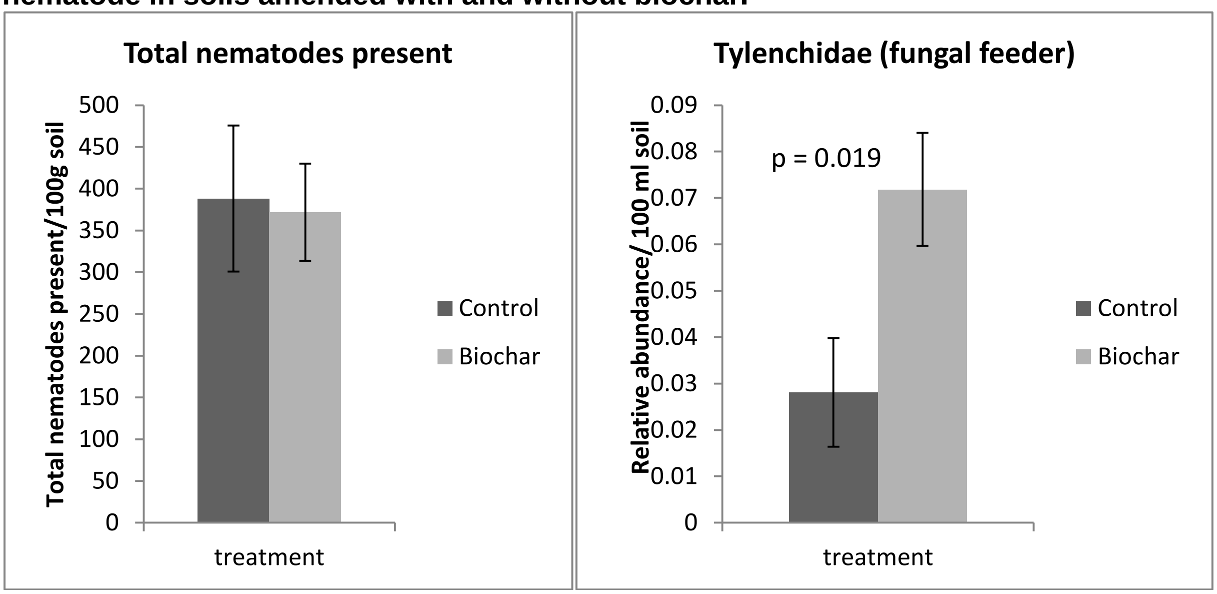
Table 1: Initial and final soil quality properties following the amendment of high temperature walnut shell biochar to soils growing lettuce after one year following amendment.

Treatment	Soil C (%)	Soil N (%)	C:N Ratio	PO_4-P (ppm)	K (ppm)	Lettuce Yield (g fresh wt)
Initial soils	1.6	0.1	13.3	133	970	-
Final Biochar soils	1.80	0.19	9.53	105	541	1080
Final Control soils	1.57	0.19	8.32	95	411	1101

2. **Biological changes**

- There was no significant difference in the total number of nematodes present in either soils amended with biochar or not.
- There was a significant difference in the fungal feeding species Tylenchidae between treatments where biochar treatments had the greatest relative abundance of this species.

Figure 1: Total number of nematodes present and relative abundance of a fungal feeding nematode in soils amended with and without biochar.



Conclusions/Future work

- **Biochar additions to soil have the ability to retain nutrients and enhance C sequestration when they may otherwise be depleted in similar systems without the addition of biochar.**
- **Biochar has the ability to change the biodiversity of an agro-ecosystem without negatively impacting crop yield.**
- **More research is needed to understand the impact of original biomass material (feedstock) and pyrolysis conditions (i.e. high or low temperature production) upon soil physical, chemical and biological properties.**