Green use of black gasification biochar
Microbial community diversity and function in a Danish sandy loam amended with straw gasification biochar - a field study
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INTRODUCTION

Biochar is char made from biomass during the production of bioenergy via pyrolysis. The chemical properties of the biochar strongly depend on the feedstock and the process. Despite the numerous proposed benefits of biochar (2), fundamental knowledge on environmental risks of adding biochar to agricultural soil is lacking (5). Knowledge gaps include biochar effects on:
- native soil microorganisms abundance, ecology and community composition
- soil functions and activity of microorganisms

Concern regarding the impact of bio-energy residues in soil leads to exclusion of biochar from current agricultural practice (1). Especially further investigations at field conditions, on both short and long term, considering specific biochar quality and original feedstock and soil type are needed (3).

Here, we present a field study using wheat straw gasification-biochar (SGB) from DONG Energy in Denmark.

RESULTS

1. SGB had a liming effect and is not toxic

<table>
<thead>
<tr>
<th>Treatments</th>
<th>pH mean (SDM, n=3)</th>
<th>Soil toxicity (residue %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(H) High SGB (10 tons ha−1)</td>
<td>7.42 (0.150)</td>
<td>0.6 (0)</td>
</tr>
<tr>
<td>(L) Low SGB (2.5 tons ha−1)</td>
<td>7.26 (0.079)</td>
<td>0.4 (0)</td>
</tr>
<tr>
<td>(F) straw</td>
<td>7.52 (0.035)</td>
<td>0.8 (0)</td>
</tr>
<tr>
<td>(C) No SGB No straw</td>
<td>6.95 (0.046)</td>
<td>0.2 (0)</td>
</tr>
</tbody>
</table>

Fig. 1 Field treatments, soil pH and BioFix® test

Effect of the four treatments on pH and toxicity in soil. Significant differences are indicated with different letters within each column (p<0.05, Tukey).

2. SGB did not alter catabolic potential of microbiota

Fig. 2 Most probable numbers of protists (MPN)

Effect of the four treatments on soil protist community size. MPN were counted 3 weeks after incubation in growth substrate. flagellates are evenly present at all conditions tested (data not shown). No significant effect was observed. Error bars indicate SEM (n=3).

3. SGB did not alter catalytic potential of soil communities

Respiration rates (0-6 hours) after addition of different substrates (GLU: glucose, GAL: galactose, NAG: n-acetyl glucosamine, GABA: γ-aminobutyric acid, AKET: α-ketoglutarate, MAL: malic acid and CIT: citric acid).

No significant effect was observed. Error bars indicate SEM (n=3).

4. SGB did not alter soil bacterial community structure

Relative abundance

- Unclassified
- Others
- Acidobacteria
- Proteobacteria
- Actinobacteria
- Firmicutes
- Acidocobacteria
- Archaebacteria
- Others
- Unclassified

Fig. 3 Catabolic profile of soil communities

5. SGB enhanced dioxygenase and reduced cellulase activities

Fig. 5 Enzymatic activity assay

Effect of the four treatments on alkaline phospho-monoesterase (Ak), acid phospho-monoesterase (Ac), phospho-diesterase (dp), α-amylase (ArSull), β-glucosidase (Gl), protease (Prot) cellulase (Cell) and dioxygenase (Diox).

Enzymatic activities are expressed as mg PNP g−1h−1, except for Diox (unit enzyme g−1 H2O and Prot [μg Tyr g−1 h−1]). *, ** indicate significant differences with p<0.05 and p<0.01, respectively (Tukey). For Cell: H vs C; for Diox: H vs all treatments.

Fig. 4 16S DNA sequencing: bacterial community structure

Effect of the four treatments on relative abundances of the dominant phyla in soil bacterial community. Construction of V3-V4 amplicons library via Nextera XT, AMPure XP beads and sequencing (spiking 5% phix DNA) via Illumina MiSeq. Analysis via 16S Metagenomics App in Illumina BaseSpace.

CONCLUSIONS

High levels of gasification-biochar (SGB) in Danish agricultural soil:
- has a significant liming effect
- is a microbiologically benign amendment
- does not alter the number of cultivable protists
- maintain bacterial community structure largely unaltered
- does not alter soil catabolic potential for the 7 substrates tested
- does not alter most of the enzymatic activities measured

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