Greenhouse gas emissions from biochar-amended soil

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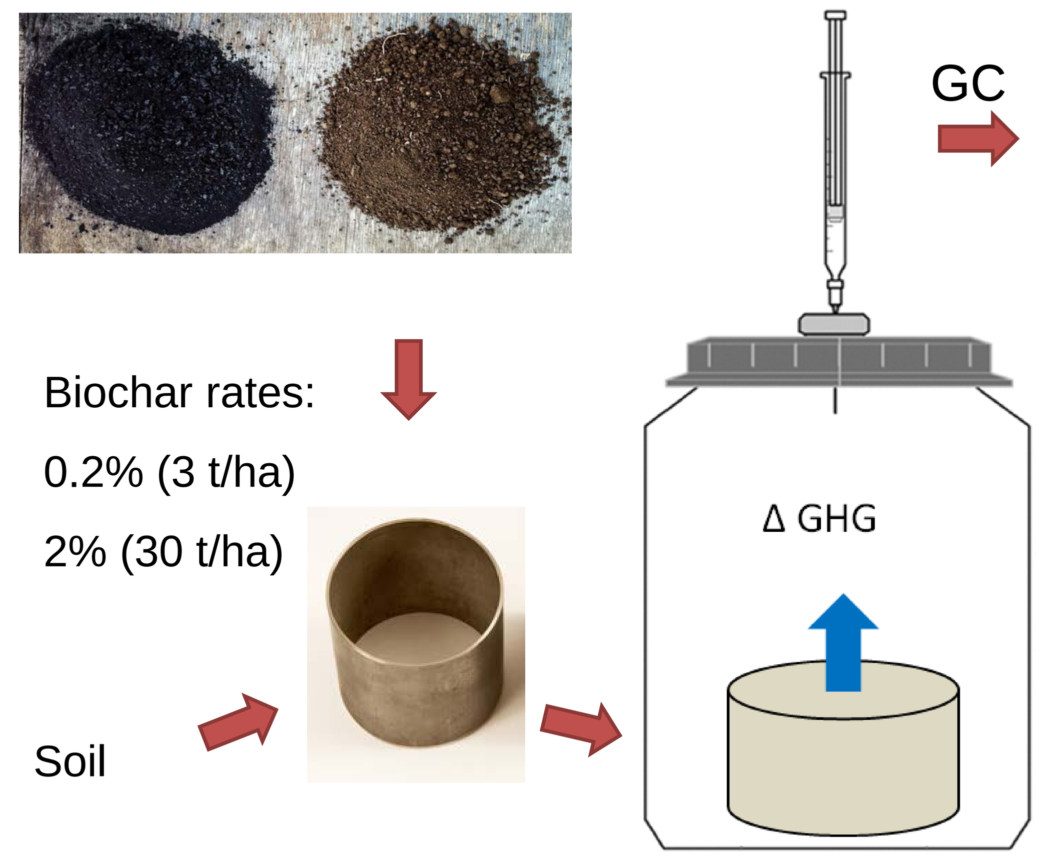
Lars Elsgaard and Sandhya Karki,
Department of Agroecology, AU, Denmark

REFERTIL



Introduction

Empirical evidence suggests that biochar can have a conspicuous effect on greenhouse gas (GHG) emissions from soil. For example, an updated meta-analysis showed that biochar reduced nitrous oxide (N_2O) emissions by 49% (grand mean) at an average application rate of 1.4% (Cayuela et al., 2015). The reductions were higher in controlled laboratory experiments than in field studies where numerous environmental factors may interact. Several hypotheses have been proposed (and tested), but so far, we lack a mechanistic understanding of the biochar effects on soil GHG emissions. In the present study, we addressed the short-term emissions of N_2O, carbon dioxide (CO_2), and methane (CH_4) in relation to biochar amendment and interactions with inorganic and organic soil N sources represented by mineral fertilizer and pig slurry, respectively. Data presently shown are for straw biochar at rates of 0.2 and 2.0%.

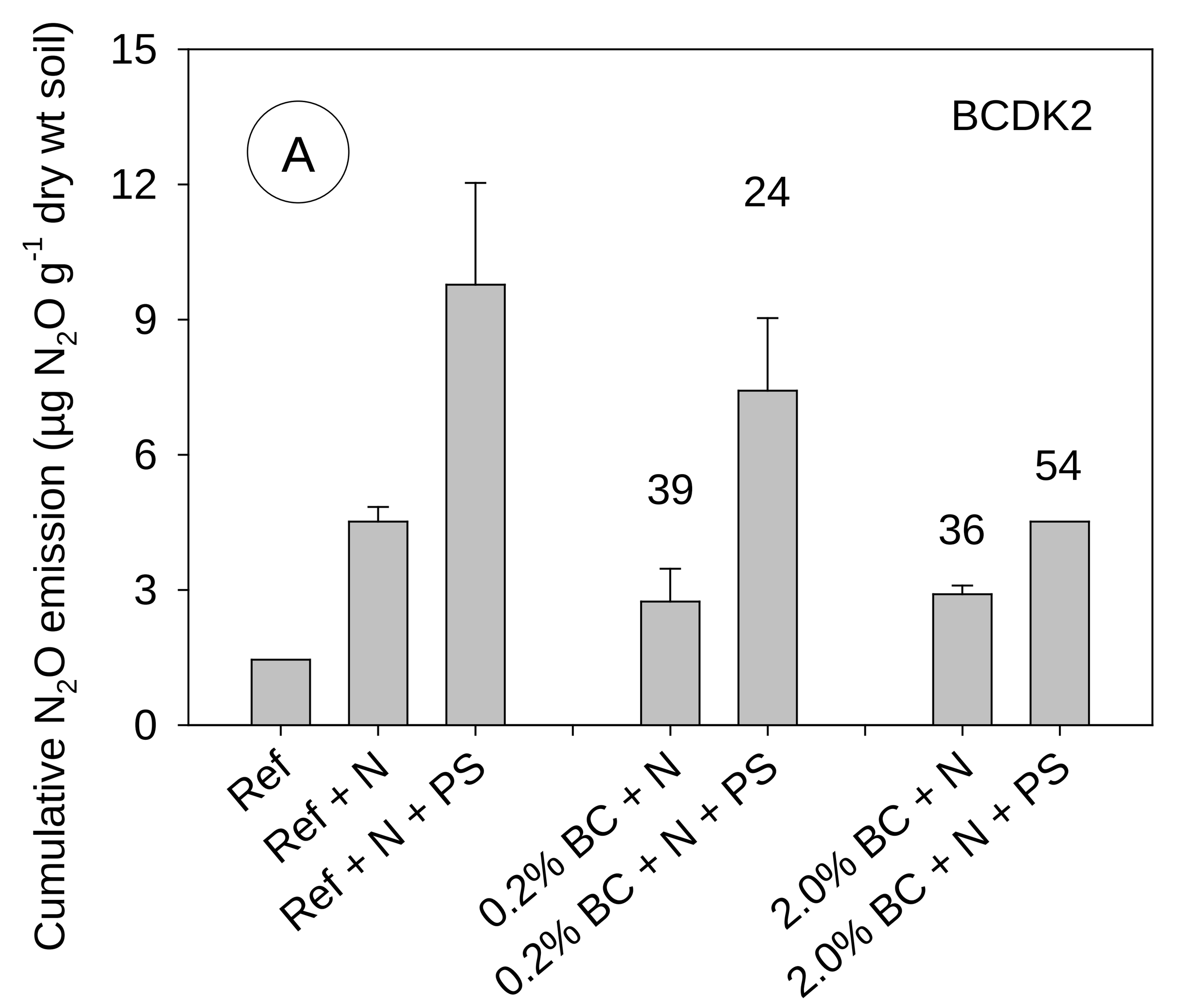
Treatments & protocol

-BC, biochar (0.2, 2.0%)
-PS, pig slurry (0, 20 Mg/ha)
-N, NO_3^- (50 mg/kg)
-Ref, reference (soil)

-3 replicates
-2 biochar types
-3 wk incubation, 20°C
-14 measurement dates
-N_2O, CO_2 and CH_4 by GC

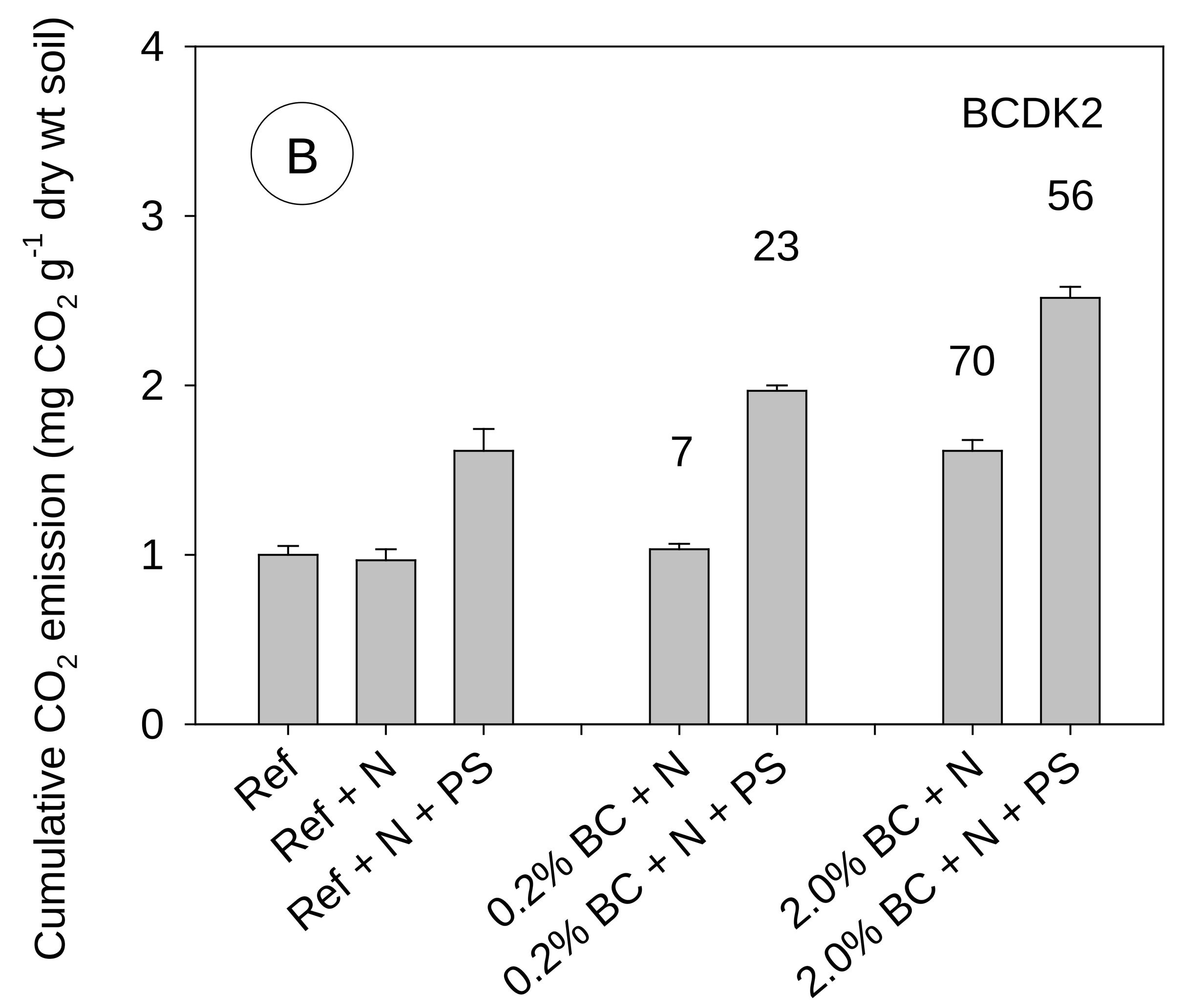
Figure captions A, B, C

GHG emission from repacked soil cores with or without straw biochar (BCDK2) in treatments with added nitrate and pig slurry. **Ref**, soil without biochar; **N**, NO_3^- added (50 mg/kg); **PS**, pig slurry added (20 Mg/ha). Data are mean ± standard error (*n*=3). Numbers above bars show percent difference between treatments with biochar and respective references without biochar. The panels show: (A) N_2O; (B) CO_2; (C) CH_4. GHG emission rates are shown as cumulative values (21 d) and highlight the relative differences between treatments.



Biochar interaction with soil N cycling and emission of greenhouse gases

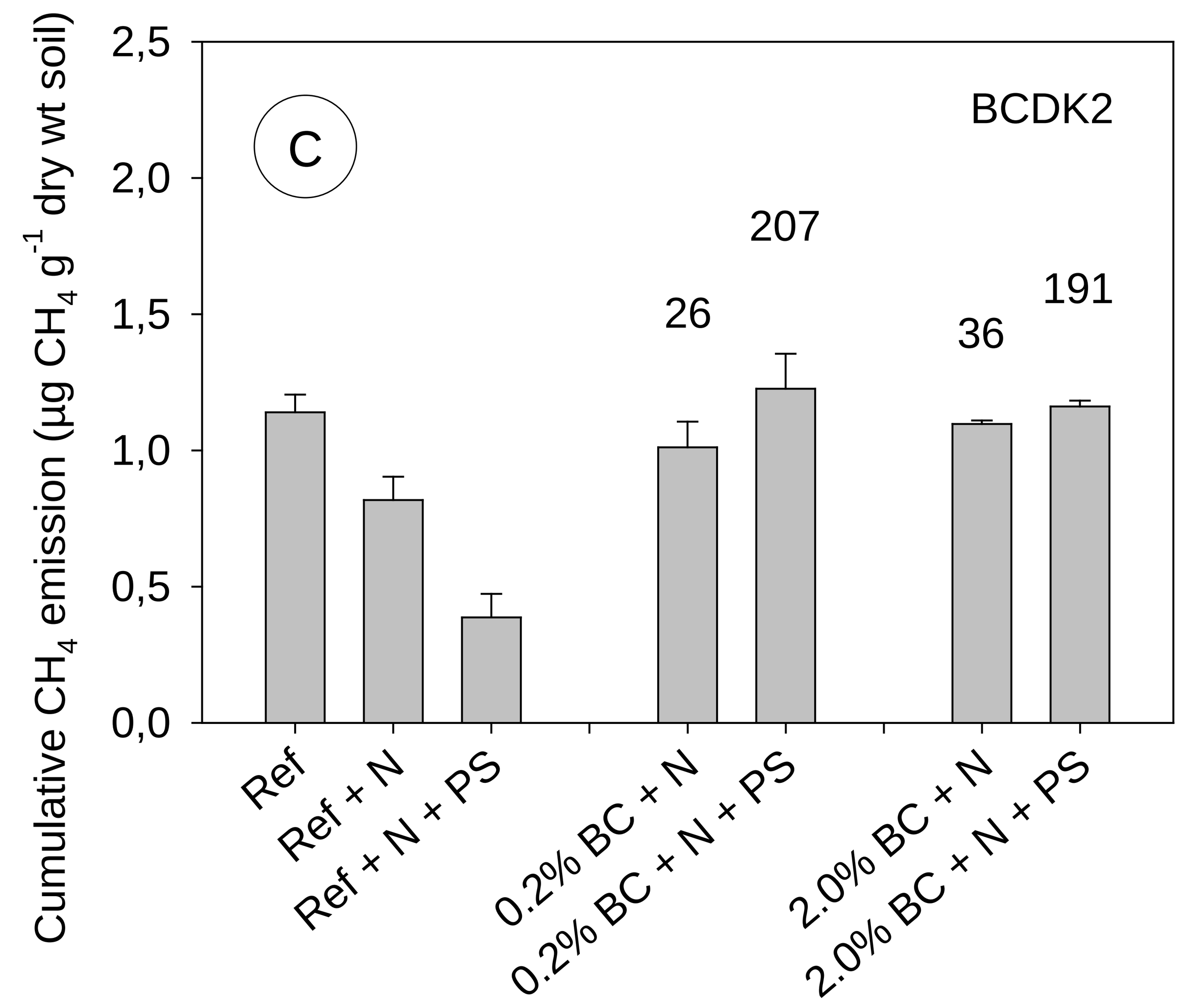
Effects of biochar application to soils on climate change mitigation perspectives were tested for N_2O, CO_2 and CH_4 in controlled laboratory experiments with two types of biochar: BCDK2 (plant-based biochar from wheat straw) and ABCHU (animal bone-based biochar). To mimic field conditions repacked soil cores (4 cm high x 6 cm diameter) were used for incubation of treatments including different levels of pig slurry (corresponding to 0, 20 Mg/ha), nitrate (50 mg/kg), and biochar rates (0.2 and 2%, wt/wt). All treatments were made in triplicates and incubated during a 3-week period under dark conditions with controlled moisture. At 14 individual measurement days, soil cores were individually transferred to 1-L glass jars that was tightly closed. One hour after closing the jars, gas samples were withdrawn from the headspace and analysed for production of N_2O, CO_2 and CH_4 by gas chromatography.



Nitrous oxide emissions were evident from the repacked soil cores, and the emissions were clearly stimulated by N availability both in inorganic and organic form (Fig. A). When biochar was added to the soil ecosystem, less N_2O was emitted; for the wheat straw biochar (BCDK2) the reduction were in the range of 24-54%, with a grand mean of 39%. For the other biochar tested (ABCHU), reductions in N_2O emissions were less certain (mean, 7%; data not shown).

Carbon dioxide emissions increased in soil with organic, but not with inorganic N (Fig. B). When biochar was added, an increase in CO_2 emission was seen, notably at 2.0% biochar. For BCDK2 the increase was in the range of 7-70%; for bone-based biochar the increase was at a lower range (mean, 16%; data not shown). Sources of CO_2 could be from stimulated microbial turnover of native soil/slurry C, but also from minor fractions of readily available biochar C.

Methane emissions in reference soils showed a decrease in response to N amendment (Fig. C). However, an interaction between N sources (notably pig slurry) and biochar resulted in drastic increases in the CH_4 emissions; this was notably the case in soil systems with pig slurry as N source. Here increases ranging up to 207% for plant-based biochar (BCDK2) were observed, whereas increases up to 344% were observed for bone-bases biochar (data not shown).



The results align with the notion of conspicuous effects of biochar on GHG emissions from soil. Further interpretation and mechanistic understanding of the interaction between GHG emissions, biochar types, and environmental factors is needed to provide robust predictions of biochar effects on GHG emissions on a wider field scale. Further work on this is in progress.

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Cited reference: Cayuela et al. (2015). Agric Ecosyst Environ 202, 135-138