Factors affecting stability of biochar and effect of biochar on stability ofsoil organic matter

Bruun, Sander; El-Zahery, T.; Clauson-Kaas, Anne Sofie Kjærulff

Publication date:
2010

Document version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Bruun, S., El-Zahery, T., & Clauson-Kaas, A. S. K. (2010). *Factors affecting stability of biochar and effect of biochar on stability ofsoil organic matter*. Abstract from International Biochar Conference IBI 2010. Progressing from Terra Preta de Indios to the Whole World, Rio de Janeiro, Brazil.

3rd International Biochar Conference
IBI 2010
Progressing from Terra Preta de Índios to the Whole World

Factors affecting stability of biochar and effect of biochar on stability of soil organic matter

Bruun, S[a]*; El-Zahery, T[b]; Clauson-Kaas, S[a];

[a] Department of Agriculture and Ecology, University of Copenhagen, Thorvaldsensvej 40, DK-1871 Frederiksberg C, Denmark; [b]Soils Department, Faculty of Agriculture Mansoura University, El Mansoura, Egypt
E-mail: sab@life.ku.dk

Key words: *Biochar stability, laboratory incubation, Radiocarbon labelling*

Introduction

The stability of biochar is of importance both in terms of the ability for biochar to act as a measure for climate change mitigation and for the ability of biochar to provide sustained improvement of soil fertility.

The high resistance to degradation of a fraction of biochar is demonstrated by the high ^{14}C age of charcoal particles [1,2]. Furthermore, incubation [3,4] and chronosequence [5] experiments have shown that it is degraded slowly compared with other types of natural organic materials.

However several aspects of biochar degradation are still inadequately studied. The effect of the degree of thermal alteration i.e. the temperature under which the biochar has been produced has mainly been investigated a lower temperatures than those relevant for commercial biochar production, and hardly anything is known about how biochar interacts with the mineral soil and how this affects the stabilization. Recently, an experiment from Sweden indicated the biochar increases the degradation of plant litter [6]. If biochar increases decomposition of other types of organic matter, the release of carbon dioxide from the soil organic matter (SOM) may offset the carbon sequestered in the biochar.

We conducted several incubation experiments using ^{14}C labelled biochar to investigate these issues. In the first experiment, ^{14}C labelled biochar was produced at different temperatures in the range from 400°C to 600°C, and incubated in different soils at the same water potential. In a second experiment we investigated the effect of biochar on the stability of other types of organic matter. To investigate the effect of biochar on the degradation of SOM, a soil that had been incubated 40 years ago with ^{14}C labelled barley straw was incubated with different amounts of biochar. To investigate the effect of biochar on litter decomposition, ^{14}C labelled plant material was incubated with and without biochar.

Results and Discussions

The results of the first experiment showed that the stability of biochar is increasing with the production temperature. When the production temperature increases from 400°C to 500°C, the fraction of added C which is evolved as CO_2 is reduced considerably (Figure 1). When the production temperature is increased from 500°C to 600°C a larger fraction of the added C is evolved in the beginning of the experiment. However, the content at carbonates is also greater in the biochar produced at 600°C. Therefore, the increased CO_2 evolution early in the experiment is likely to come from carbonates contained in the biochar [7]. After the carbonates have disappeared, the CO_2 evolution is lower from the biochar produced at 600°C than at 500°C.

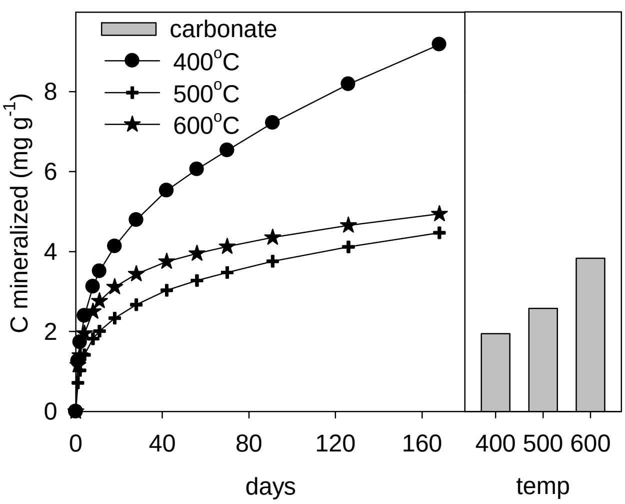

Figure 1. Mineralization of C and C in carbonates of biochars produced at 400°C, 500°C and 600°C.

The interpretation that most of the CO_2 evolution early in the experiment stems from carbonates is supported by the fact that the soils with low pH are releasing CO_2 faster in the beginning than the soils with a high pH. Apart from the effect of pH, the soil type seemed to have little effect on the CO_2 evolution. This indicates that interactions with the soil matrix do not affect the stabilization of biochar within the duration of the experiment.

Although the amount of carbonates in biochar would depend very much on the way it is produced, the initial burst of CO_2 evolution often observed in mineralization experiments of biochar may in fact come from carbonates. This means that the fraction of biochar which is easily degraded may be due to carbonates and biochar may be more stable than expected from the results.

In the second experiment the ^{14}C labeled SOM in the soil labeled 40 years ago mineralized more slowly the more biochar that was added (Figure 2).

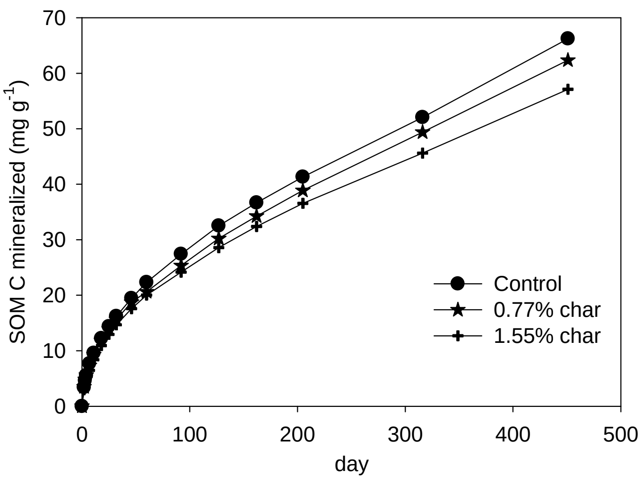

Figure 2. Mineralizaion of SOM C from a control soil and soils amended with different amounts of biochar

The effect of biochar on the mineralization of litter was very small. Without biochar 48%±0.2% of the litter C was mineralized and with addition of 0.15% biochar, 45%±1.6% was mineralized.

The reason for the decreased release of CO_2 from SOM and litter upon addition of biochar can be manifold. First, the addition of biochar may change water availability by absorption. Secondly, microorganisms degrading biochar may immobilize N and impose N limitation on SOM decomposition. The slow decomposition of biochar and the fact that N was added to the soil means that this is not considered the primary reason for the decreased decomposition. Addition of biochar increases the pH of the soil. However, this would most often increase decomposition of SOM.

Therefore, the reduction of water availability may be one of the primary reasons for the reduced CO_2 evolution resulting from addition of biochar. Unfortunately this reduction of water availability does not correspond with what would happen under field conditions and therefore it is problematic to conclude that biochar reduces the decomposition of SOM and litter. We can however conclude that there was no indication that biochar addition decreased the stability of litter and SOM.

Conclusions

We can conclude that the production temperature of biochar affected the stability of biochar strongly producing more and more stable biochar the higher the temperature. However, the CO_2 evolution right after the addition of the biochar also depends on the carbonate content which increases with production temperature.

The fact that the CO_2 evolution early in the experiment may come from carbonates may also be true in other experiments and the fraction of biochar which is easily degraded may be smaller than expected.

The pH of the soils also affected the CO_2 evolution from carbonates, but apart from this the soil type seemed to have little effect on the CO_2 evolution.

Biochar did not seem to increase the mineralization of SOM. On the contrary less CO_2 was evolved from the incubations with large biochar additions. Although this may be explained by decreased water availability after biochar additions which would not happen under field conditions, it must be concluded that there was no evidence of decreased stability of litter and SOM after biochar addition.

Acknowledgements

The study was financially supported by Gluds Legat and SJVF (Grant no. 23-03-0102).

1 Carcaillet, C. 1998. J. Ecol., 86, 384-396.
2 Titiz, B.; Sanford, R. L. 2007. Biotropica, 39, 673-682.
3 Bruun, S.; Jensen, E. S.; Jensen, L. S. 2008. Org. Geochem., 39, 839-845.
4 Kuzyakov, Y.; Subbotina, I.; Chen, H. Q.; Bogomolova, I.; Xu, X. L. 2009. Soil Biology & Biochemistry, 41, 210-219.
5 Nguyen, B. T.; Lehmann, J.; Kinyangi, J.; Smernik, R.; Riha, S. J.; Engelhard, M. H. 2009. Biogeochem., 92, 163-176.
6 Wardle, D. A.; Nilsson, M. C.; Zackrisson, O. 2008. Science, 320, 629.
7 Bertrand, I.; Delfosse, O.; Mary, B. 2007. Soil Biology & Biochemistry, 39, 276-288.