Carbon Distribution in Humic Substance Fractions Extracted from Soils Treated with Charcoal (Biochar)

B.E. Madari, L.B. Lima, M.A.S. Silva, E.H. Novotny, F.A. Alcântara, M.T.M. Carvalho, and F.A. Petter

Abstract Biochar incorporation into the soil is a proposed C sequestration strategy. How newly applied biochar affects C accumulation in the soil is therefore a relevant question. This study presents part of the results, obtained from field experiments, of a study which has as objective to contribute to elucidate this question. The results indicated that biochar application into the soil directly influences humic substance levels. This effect is most probably due to the dichromate oxidable C contained in the biochar itself. This abstract and the abstract by Novotny et al. in this anais are containing complementary information as the latter characterized the HS fractions extracted from the same samples of the sandy loam discussed in this abstract.

Keywords Biochar • Pyrogenic carbon • Fulvic acids • Humic acids • Humin • Quantification

B.E. Madari (✉) • F.A. Alcântara •
M.T.M. Carvalho
Embrapa Rice and Beans, Caixa Postal 179, Santo Antônio de Goiás, GO CEP 75375-000, Brazil
e-mail: madari@cnpaf.embrapa.br

L.B. Lima • M.A.S. Silva
Embrapa Rice and Beans, Caixa Postal 179, Santo Antônio de Goiás, GO CEP 75375-000, Brazil

Federal University of Goiás, Caixa Postal 131, Goiânia, GO CEP 74690-900, Brazil

E.H. Novotny
Federal University of Piauí, Embrapa Soils, Rua Jardim Botânico, 1024,
Rio de Janeiro, RJ CEP 22460-000, Brazil

F.A. Petter
Federal University of Piauí, Bom Jesus, PI CEP 64900-000, Brazil

J. Xu et al. (eds.), *Functions of Natural Organic Matter in Changing Environment*,
DOI 10.1007/978-94-007-5634-2_185,

Introduction

Anthropogenic dark earths (ADE or, in Portuguese, *Terras Pretas de Índio*) are soils widely observed in the Amazon. According to our recent knowledge, ADE were formed by indigenous populations in the pre-Columbian era who deposited carbonized biomass of different origin into the soil. The most important property of these soils, which makes them interesting in the search for a new and adequate model for sustainable agriculture in tropical areas, is their great productivity potential compared to adjacent soils that lack the archeo-anthropogenic A horizon. This soil horizon is characteristic for ADE soils, and its uniqueness is in its elevated organic C content and the quality of this C. It is highly stable and at the same time chemically reactive, in other words, persistent in the soil and has high CEC, this way contributing to relatively high and sustainable fertility in an environment that otherwise favours nutrient leaching and fast OM decomposition.

It was shown that the humic acid fraction of the OM of ADE "inherited", at least partially, the chemical structures from the pyrogenic C (Novotny et al. 2007). It was also shown by Liang et al. (2010) that the transformation of fresh OM into more stable OM fractions in a soil that had pyrogenic C (ADE) was faster than in a soil where this type of C was not present.

It is a relevant question how newly applied biochar affects C accumulation in the soil.

The hypotheses are that besides the simple accumulation of C through adding more stable C to the soil, biochar may also affect the composition of SOM. Biochar may have this effect in depth as well, by vertically moving in the soil.

Materials and Methods

Soil samples were collected from two field experiments with different soil types and different textural classes in Brazil. One was established on June 9, 2009, in a clayey (51% clay, 40% sand) Rhodic Ferralsol at the Embrapa Rice and Beans (16°29′17″ S, 49°17′57″ W, 823 m amsl). Experimental plots were arranged in four replications, with N (0, 30, 60, 90 kg ha^{-1}) and biochar (0, 8, 16, 32 Mg ha^{-1}) applied in four doses, in both experiments. Biochar was incorporated into the soil at 0–10 cm using a disc harrow (June 2009). The other experiment was installed in December 2008, in a Dystric Plinthosol, textural class sandy loam (17% clay, 76% sand), at Cruzeiro do Sul farm (14°41′48″ S, 52°20′55″ W, 310 m amsl). Biochar was incorporated at the same depth in December 2008.

Biochar was applied in the soil only once. The source of the biochar was *Eucalyptus* sp. charcoal from plantation, by traditional carbonization at 400–550°C. The fine of the char was milled to pass 2-mm sieve before applying to the soil and contained 77% C, 0.3% N, 5 ppm P, 60 ppm K, 0.06% Ca and 0.03% Mg, among other elements. The dichromate oxidable organic C was 3.3%.

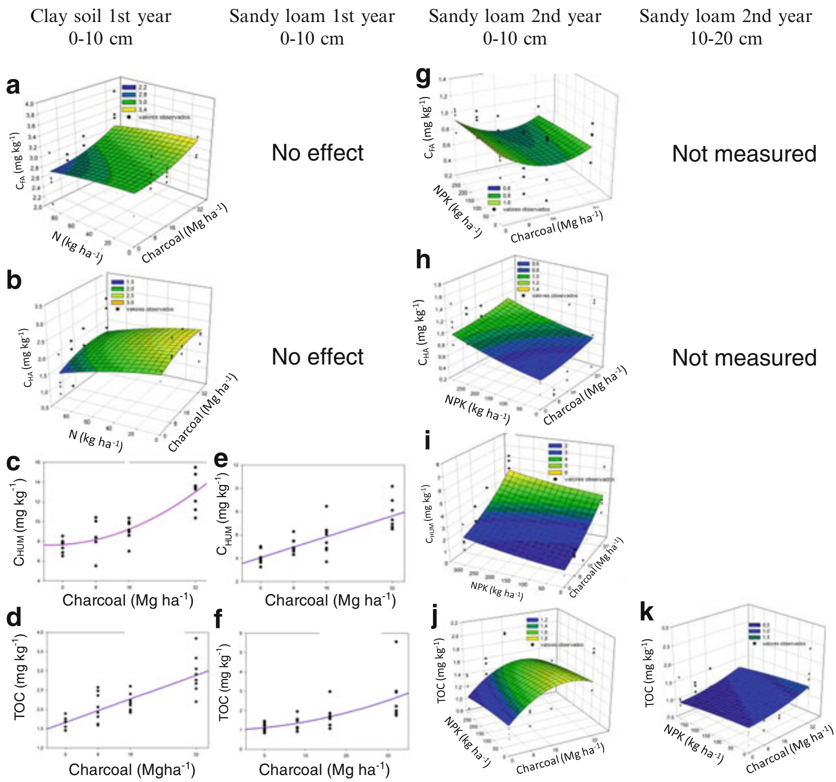

Fig. 1 The effect of biochar (*Eucalyptus* charcoal) and N (NKP) on the humic substance fractions and on the total organic C (TOC) content. *FA* fulvic acids, *HA* humic acids, *HUM* humin. *p* of the regressions is always less than 0.015. Regression equations are not shown

In the clay soil samples were collected within the first year of the application of biochar, in the sandy loam in the first and second year.

For the humic substance extraction and quantification, a modified IHSS procedure was employed. The fulvic acid (FA), humic acid (HA) and humin (HUM) fractions were quantified in the soil samples. The total organic carbon (TOC) was determined by high-temperature dry combustion using a PE Elemental Analyzer Series 2400 CHNS.

Variance analysis (PROC MIXED for the experiment in the clay soil and GLM for the experiment in the sandy loam) and regression analysis (RSREG) were done using the SAS software package.

Results and Discussion

In clay soil, in the first year after the application of biochar, it had a combined effect with N on FA (Fig. 1a) and HA (Fig. 1b) concentrations in the soil. For HUM, however, only biochar had effect (Fig. 1c).

In the sandy soil, in the first year of application, biochar had no effect on FA and HA, however, positively influenced HUM concentrations (Fig. 1e).

In the second year after biochar application in the sandy soil, it had combined effect with N on FA (Fig. 1g) and HA (Fig. 1h), as did in the clay soil already after 1 year, and also for HUM (Fig. 1i).

These results indicate that recently added biochar into the soil directly influences the distribution of C among the humic fractions, having positive effect and proportional to the applied doses. It is however highly possible that the increase in the HS fractions in the soil happened because of the extractable organic C content of the biochar itself. A related abstract, examining the same samples, at this conference is providing confirmation to this hypothesis. Also, biochar would rarely be applied to the soil alone; it is used combined with synthetic fertilizers that, in this case, for N was urea. A known effect of urea is lowering soil pH, and this effect is probably affecting HS solubility.

In the first year after the application of biochar, it positively affected TOC concentrations in both the clay and sandy soil (Fig. 1d and f, respectively). In the sandy soil we had the opportunity to evaluate the second year after biochar application as well, and then the biochar had a combined effect with N on TOC (Fig. 1j).

In the same soil TOC was also evaluated in the layer immediately under the application depth of biochar (10–20 cm), where, in the first year, biochar had no effect on its concentrations, but in the second year it had a combined effect with N on this variable (Fig. 1k). This information confirms the hypothesis that biochar, depending on the soil texture and therefore on soil structure and porosity, may vertically move within the soil profile.

Acknowledgements CAPES, Embrapa, CNPq, UFG

References

Liang, L., J. Lehmann, S.P. Sohi, J.E. Thies, B. O'Neill, L. Trujillo, J. Gaunt, D. Solomon, J. Grossman, E.G. Neves, and F.J. Luizão. 2010. Black carbon affects the cycling of non-black carbon in soil. *Organic Geochemistry* 41: 206–213.

Novotny, E.H., E.R. Azevedo, T.J. Bonagamba, T.J.F. Cunha, B.E. Madari, V.M. Benites, and M. H.B. Hayes. 2007. Studies of the compositions of humic acids from Amazonian dark earth soils. *Environmental Science and Technology* 41: 400–405.