Biochar Makes Soil Organic Carbon More Labile, but Its Carbon Sequestration Potential Remains Large in an Alternate Wetting and Drying Paddy Ecosystem

Wanning Dai[1,2,3,4], Zhengrong Bao[1,2,3,4], Jun Meng[3,4], Taotao Chen[5]*, Xiao Liang[1,2]*,

1 School of Agriculture, Liaodong University, Dandong 118001, China

2 Institute of Advanced Characteristic Agriculture Studies of Liaodong University

3 College of Agronomy, Shenyang Agricultural University, Shenyang, 110866, China

4 National Biochar Institute of Shenyang Agricultural University, Key Laboratory of Biochar and Soil Improve-ment, Ministry of Agriculture and Rural Affairs, Shenyang, 110866, China

5 College of Water Conservancy, Shenyang Agricultural University, Shenyang 110866,

*Correspondence: taotao-chen@syau.edu.cn (T, Chen); miyou0511@163.com (X, Liang)

1. Supplementary data

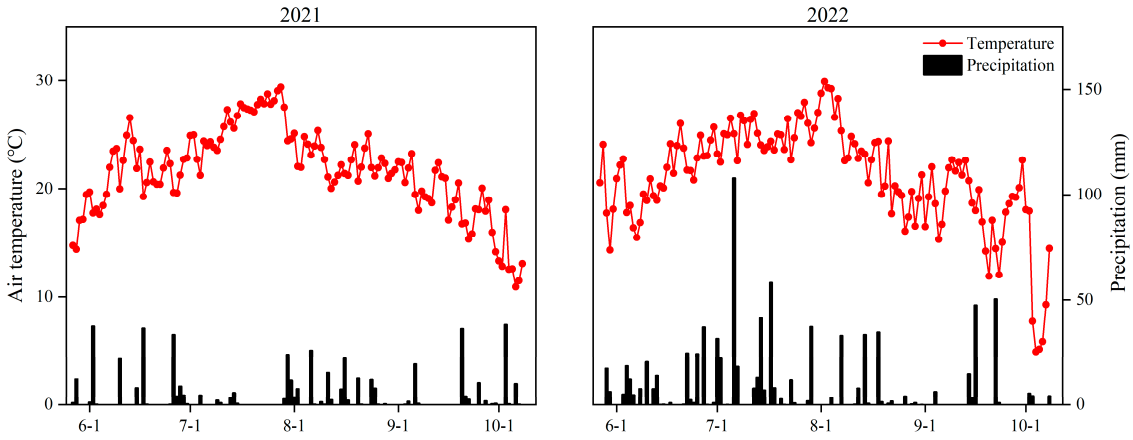

Figure S1

Daily average air temperature and precipitation throughout the 2021 and 2022 rice growing periods in Shenyang, China.

Analytical Methods:

To extract the DOC, 20 g of soil was shaken with 40 mL of deionized water in a 100 mL centrifuge tube for 30 min at 180 revolutions per minute (rpm) and then centrifuged for 20 min at 4000 rpm (Ghani et al., 2003) [36]. A 45 μm filter membrane was used to filter the supernatant. Then, the organic C content in the filtrate was immediately analyzed using a Total Organic Carbon analyzer (Multi N/C 3100 TOC, Elementar, Germany).

The MBC was estimated from the increase in organic C in the 0.5 mol L^{-1}1potassium sulfate (K_2SO_4) extracts of chloroform fumigated soils compared to unfumigated extracts, and following a factor of 0.45 was applied to calculate MBC (Wu et al., 1990) [37].

POC was measured by particle size as described by Cambardella and Elliott (1992) [38]. In brief, 10 g of oven-dried soil was placed in a 250-mL flask, dispersed with 30 mL of 5 g L^{-1} sodium hexametaphosphate solution, and shaken horizontally approximately for 18 h. The dispersed sample was then passed through a 0.053 mm sieve and the material remaining on the sieve (>0.053 mm) was dried in a forced air oven at 60 ◦C. The organic C in the suspended fraction represents POC. The analysis of the organic C content of the particulate matter followed the same method used for SOC determination.

The LFOC was determined using the density fractionation method as described by Gregorich and Janzen (1996) [39]. Briefly, 10 g of air-dried soil (<2 mm) was placed in a 100 mL centrifuge tube with 50 mL of NaI solution (1.70 g cm^{-3}). After shaking and centrifuging, the supernatant with floating particles was decanted into a vacuum filter unit with a glass-fiber filter. The process was repeated twice without sonication. The light fractions were then washed three times with deionized water, oven-dried at 60 ℃ for 48 h, weighed, and stored for analysis. The analysis of the organic C content of the light fraction followed the same method used for SOC determination.

The EOC was determined following Blair et al. (1995) [5]. Briefly, a finely ground air-dried soil sample containing about 15 mg C was weighed into 50-ml centrifuge tubes, and 25 mL 333 mM $KMnO_4$ was added. the soil suspension was shaken for 1 h at 200 rpm and then centrifuged for 5 min at 2000 rpm. The supernatant was diluted 250 times with deionized water and the absorbance of the diluted solution was determined at 565 nm. Estimation of the amount of C oxidized was based on the changes in the concentration of $KMnO_4$, assuming that 1 mM $KMnO_4$ was consumed in the oxidation of 9 mg of C.

Blair, G.J., Lefroy, R.D.B., Lisle, L., 1995. Soil carbon fractions based on their degree of oxidation, and the development of a carbon management index for agricultural systems. Aust. J. Agric. Res. 46.

Cambardella, C.A., Elliott, E.T., 1992. Particulate Soil Organic-Matter Changes across a Grassland Cultivation Sequence. Soil Sci. Soc. Am. J. 56, 777-783.

Ghani, A., Dexter, M., Perrott, K.W., 2003. Hot-water extractable carbon in soils: a sensitive measurement for determining impacts of fertilisation, grazing and cultivation. Soil Biol. Biochem. 35, 1231-1243.

Gregorich, E., Janzen, H., 1996. Storage of soil carbon in the light fraction and macro-organic matter. Structure and Organic Matter Storage in Agricultural Soils, 167-192.

Wu, J., Joergensen, R.G., Pommerening, B., Chaussod, R., Brookes, P.C., 1990. Measurement of soil microbial biomass C by fumigation--extraction--an automated procedure. Soil biology & biochemistry 22, 1167-1169.