3-3 Characteristics of biochar materials produced from coconut shells and rice husks for soil application

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ABSTRACT

Our hypothesis of the study was that biochar materials produced from different raw materials and temperatures showed different effects on soil quality improvements and therefore vegetable yields. In FY2011, we examined some chemical characteristics of biochar materials produced from coconut shells and rice husks that were easily available as agricultural wastes in developing countries in the Asia-Pacific region. As a result, different raw materials and temperatures influenced chemical characteristics of biochar materials. Biochar from rice husk at higher temperature contains more silicon, which would be beneficial for crop growth. Ammonium–N (NH_4-N) and phosphate–P (PO_4-P) were considerably extracted at pH 1, especially from coconut shells biochar produced at higher temperature, as compared with other conditions. The contents of these nutrients were however small when considering fertilizer effect to crop growth.

KEYWORDS

Biochar, coconuts, nutrients, nitrogen, phosphorus, rice husk

INTRODUCTION

We intend to evaluate soil application effects (better soil quality and crop growth) of biochar produced from agricultural wastes in the Asia-Pacific region. Biochar is preferably produced from local agricultural wastes from viewpoints of treatment and material costs. Unused crop residues like coconut shells can be raw materials in rural areas in developing countries because of sufficient and constant supply.

Biochar is defined as a solid material obtained from the carbonisation of biomass (International Biochar Initiative, 2012). Benefits of biochar application to soil are: i) increased soil carbon content (carbon sequestration), ii) improved physical properties (increased water retention and drainage),

iii) decreased nutrient leaching, iv) improved fertility (nutrients release), v) reduced emissions of green house gases.

The purpose of our study is to produce better quality of biochar as soil amendment or conditioner from agricultural wastes. In this year, we evaluated the effect of different raw materials and temperatures on biochar characteristics.

INTERNATIONAL EXCHANGE

We invited Ms Tran Thi Tu from Institute of Resources, Environment and Biotechnology, Hue University, Vietnam from 4 to 6 February 2012. She delivered a presentation entitled "A study into adsorption of dye from aqueous solution by peat" at the annual meeting and we discussed about co-operative research plan in FY2012 as follows.

February 4	Attended at the 2nd Debrief Meeting of Practical Research and Education of Solid Waste Management based on Partnership between Universities and Governments in Asia and Pacific Countries
February 5	Visited to Uddin's laboratory, and discussed about the cooperative research plan
February 6	Visited to Nisshoku Corporation Insitute and Maeda's laboratory, and discussed the detailed experimental plan

MATERIALS AND METHODS

1. Biochar used

Coconut shells were collected from dumping garbage near Dong Ba Market in Hue, Vietnam in September 2011. Rice husks were provided from Nisshoku Corporation, Japan. Pyrolysis of coconut shells and rice husks was performed using a muffle furnace for 60 min at the temperature of 500 or 800 ^{o}C, with a rise rate of 10 ^{o}C min^{-1}. The yields of biochar from coconut shells were 40.5% at 500 ^{o}C and 34.0% at 800 ^{o}C, and that from rice husks 45.9% at 500 ^{o}C and 40.2% at 800 ^{o}C. The yield of biochar from coconut shells was smaller than that from rice husks. Higher temperature induced a greater yield of biochar.

2. Chemical analysis

Biochar was soaked with distilled water at a 1:10 solid water ratio then subject to pH and electrical conductivity (EC) analyses (Horiba pH/Ion Meter F-23 and Horiba Conductivity Meter, DS-14, respectively). Silicon, aluminum, and iron contents of biochar materials were measured with a fluorescent X-ray analyzer (Ourstex 140/12). Biochar was extracted with different solutions (2 *M* KCl, 0.1 *M* HCl, 1 *mM* HCl, or distilled water) at a 1:10 solid water ratio for coconut shell biochar and 1:100 for rice husk biochar, and the mixture were shaken for 60 min on a multi-shaking machine (Tokyo Rikakikai MMS-110), for determination of extractable nitrate–N (NO_3-N), NH_4-N,

PO_4-P, and SiO_2-Si. Those concentrations in extracts were analyzed with an automated continuous flow analyzer (BL-Tec QuAAtro2-HR). Cation exchange capacity was determined according to a method by Harada and Inoko (1980), in which cation exchange sites on the surface of biochar were first filled with hydrogen ions from HCl, then displaced with barium acetate.

RESULTS AND DISCUSSION

1) pH values of biochar materials were 9–10 (slightly alkali) regardless of raw materials. Electrical conductivity was higher for coconut shell biochar than for rice husk biochar. Higher pyrolysis temperature increased pH and EC of both biochar materials. (Table 1)
2) Silicon content of biochar from rice husks was greater than that from coconut shells. The Si content increased at higher pyrolysis temperature. Alminum content of biochar from rice husks was somehow higher than that form coconut shells. (Table 2)
3) Extractable NO_3-N content was greater for coconut shell biochar or at lower pyrolysis temperature. Most of NO_3-N was extracted with distilled water, indicating little ion exchange adsorption on the biochar surface. (Fig. 1)
4) More NH_4-N and PO_4-P were extracted at pH 1 and those were higher for coconut shell biochar. Because plants can take up phosphate in soil by exuding organic acids from roots (Hoffland, 1992), the acid-extractable PO_4-P from biochar will be available for plants. (Figs. 2 and 3)
5) Extractable SiO_2-Si content was higher for biochar from coconut shells at 800 ^{o}C. The extractable SiO_2-Si increase with pH. (Fig. 4)
6) Extractable contents of the nutrients were relatively low when considering the fertilizer effect of biochar. Therefore, the large amount of biochar application (>5 kg m^{-2}) is necessary to expect nutrient supplies to crops.
7) Cation exchange capacity was higher at higher temperature or for rice husk biochar. (Fig. 5)

Table 1 pH and EC of biochar materials

	pH (1:10)	EC (1:10) dS m^{-1}
Coconut shells at 500 ^{o}C	9.0	0.218
Coconut shells at 800 ^{o}C	10.0	27.1
Rice husks at 500 ^{o}C	9.4	0.0016
Rice husks at 800 ^{o}C	9.7	0.733

Table 2 Major elements in biochar materials

	Si(%)	Al(%)	Fe(%)
Coconut shells at 500 °C	0.64	0.08	0.02
Coconut shells at 800 °C	0.67	0.05	0.00
Rice husks at 500 °C	2.43	0.01	0.01
Rice husks at 800 °C	10.11	0.00	0.01

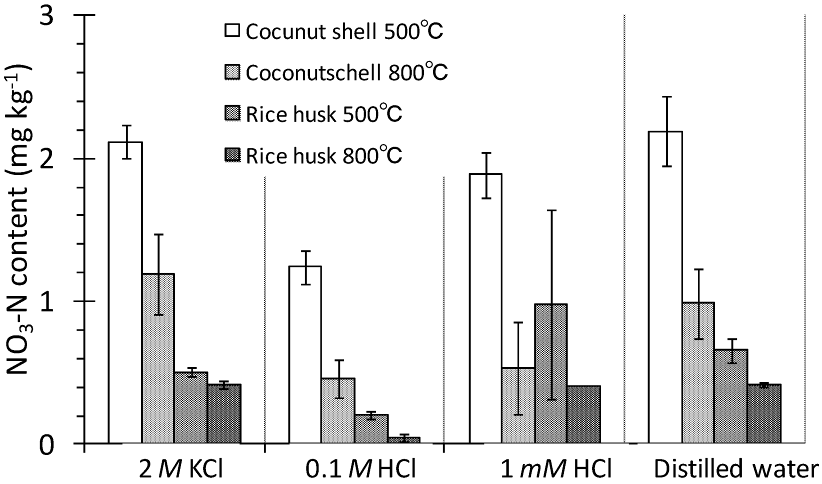

Fig. 1. Extractable NO_3-N content with different solutions.

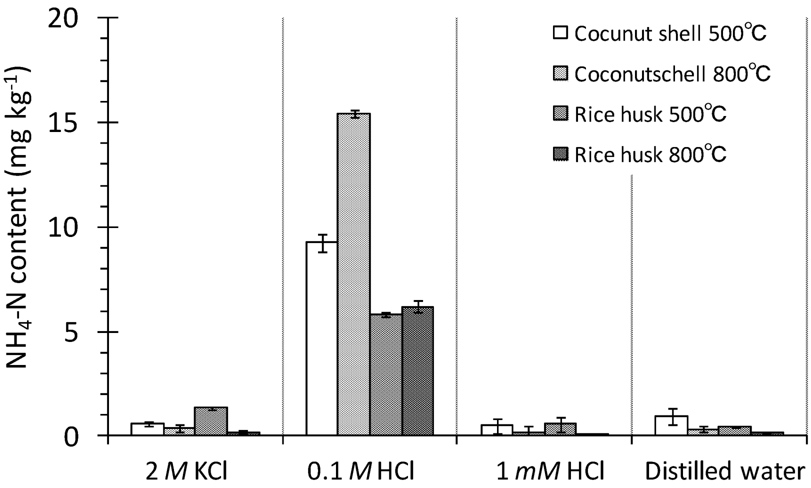

Fig. 2. Extractable NH_4-N content with different solutions.

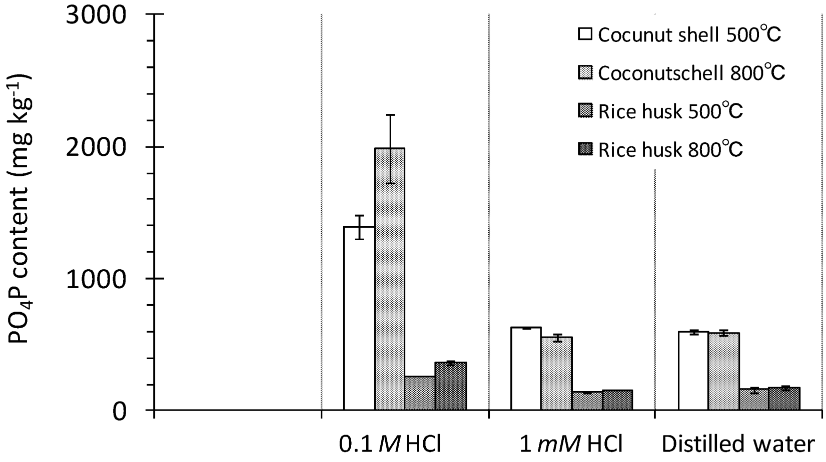

Fig. 3. Extractable PO_4-P content with different solutions.

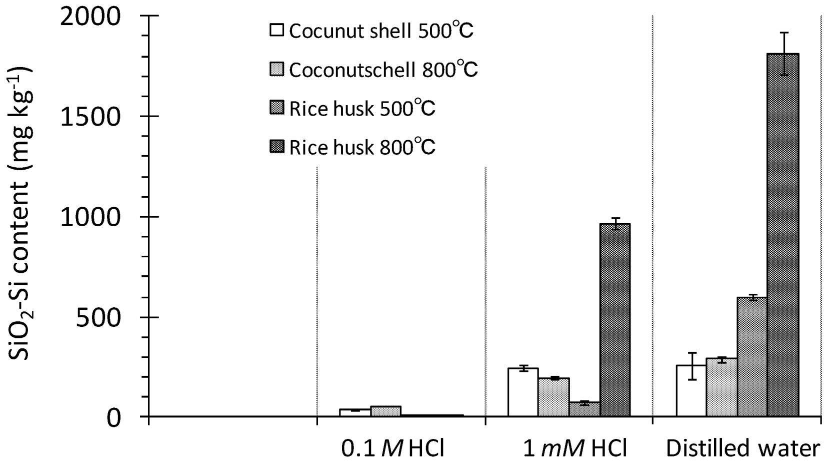

Fig. 4. Extractable SiO_2-Si content with different solutions.

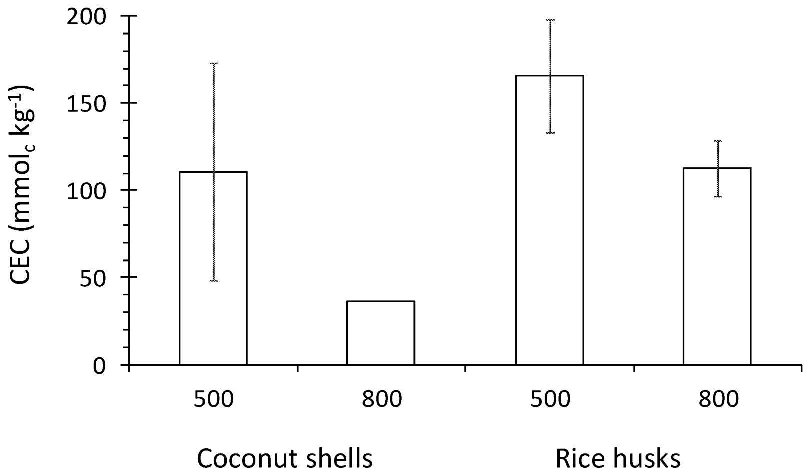

Fig. 5. Cation exchange capacity (CEC) of different biochar materials.

CONCLUSIONS AND PERSPECTIVES

Different raw materials and temperatures for biochar production influenced extractable nutrient content of biochar materials. The large amount of biochar, however, should be applied to soil when considering fertilizer effect to crop growth. We further need to study the effect of biochar application on improvement of soil physical properties (water retention and drainage conditions), which is expected for many years because of less degradation of carbon in biochar. We will also set up pot experiments to analyze the effect of different biochar materials on Komatsuna growth, nutrients leaching, and N_2O gas emissions in Japanese and Vietnamese climate and soil conditions in FY2012.

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