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Assessment and Promotion of Strategies and Techniques for the Reuse of Agricultural Straw Residues in China

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ABSTRACT: To improve the recycling of agricultural biomass residues in China, the present project surveyed the recycling patterns of agricultural waste biomass in Japan via literature review and field visits. The state of agricultural straw recycling in Tianjin suburb, China was also investigated as a case study. Biochar, as a new approach to the recycling of straw, was studied systematically to explain its possible effects on plant growth, soil microflora, and the fate of several pollutants. To disseminate the advanced strategies and technologies in biomass recycling, a monograph entitled "Biochar and Environment" will be published. As part of the project, a workshop was held and a website was constructed (http://www.shengwutan.org). In Japan there is a long history of good practice of reusing agricultural and other biomass residues, such as wood chips, to generate energy and fertilise soil. In Tianjin, the recycling of agricultural biomass residues has progressed significantly. However, the reuse rate still remains low and techniques are lagging. The study on biochar found that it could promote the growth of wheat and vegetables and immobilise heavy metals and polycyclic aromatic hydrocarbons (PAHs). Moreover, as biochar could influence the hydrolysis and biodegradation of pesticides with varying impacts dependent on its structure, it could be used for pesticide pollution control.

KEYWORDS: *agricultural straw, biomass recycling, biochar, pollution control, promotion on plant growth*

Project Objectives

The aim of the project was to transfer the advanced experience in recycling agricultural straw residues from Japan to China. The project will help solve the problems in global climate change, fossil energy crisis and agricultural solid waste treatment, promoting sustainable development in the region. The objectives were to 1) find the best scheme on the recycling of agricultural straw for China; 2) disseminate selected advanced Japanese strategies and techniques to Chinese decision makers, scientists and farmers to raise their awareness; and 3) build capacity of Chinese scientists to build capacity to conduct innovative studies on biomass reuse.

Innovative Research on Biochar

Biochar was synthesised from different kinds of agricultural biomass waste, such as the straw of wheat, rice and maize, as well as pig manure, and their properties were characterised (Figure 1). The influence of biochar on soil enzyme, plant growth and nutrition species, and the fate of several pollutants (heavy metals, PAHs and pesticides) were also studied. Biochar is composed of organic and inorganic moieties with a highly porous structure, and its properties, such as pore structure, aromaticity, and polarity vary with raw material and pyrolysis temperature. Generally, biochar can enhance the growth of wheat and vegetables (Figure 2). In addition, biochar can reduce the availability

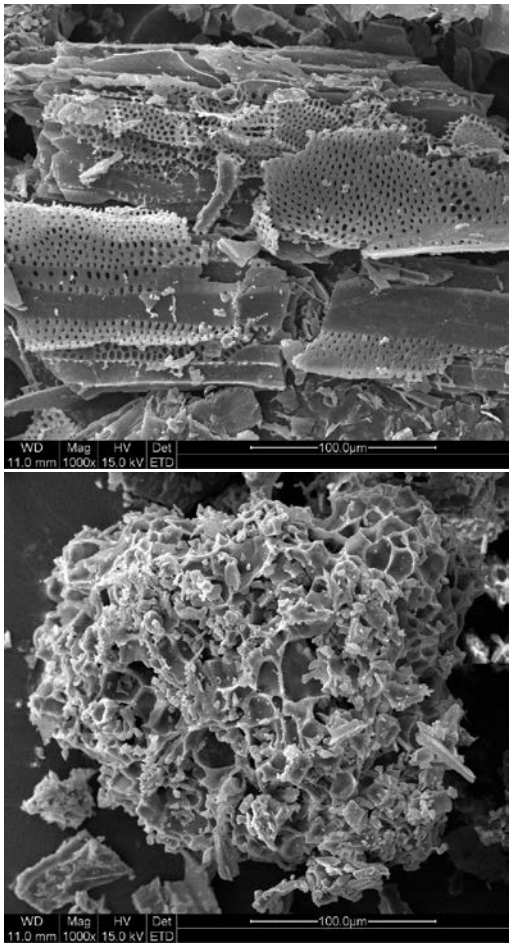

Figure 1. SEM photography of biochars (Top: corn biochar; Bottom: pig manure biochar ×5000).

Lactuca sativa var. *ramosa*

CK; Corn straw; Corn biochar; Corn biochar+N; Wheat straw; Wheat biochar; Wheat biochar+N

Amaranthus mangostanus L.

CK; Corn straw; Corn biochar; Corn biochar+N; Wheat straw; Wheat biochar; Wheat biochar+N

Figure 2. Vegetable growth in soils amended with straw and biochar.

of heavy metals and PAHs by adsorption, consequently reducing the risk of these pollutants. The influence of biochar on the fate of pesticides is complex, with several processes occurring simultaneously: adsorption, catalysed hydrolysis and enhanced or inhibited (dependent on the type of biochar) biodegradation. The research results provide valuable information for the manipulation of pesticide control.

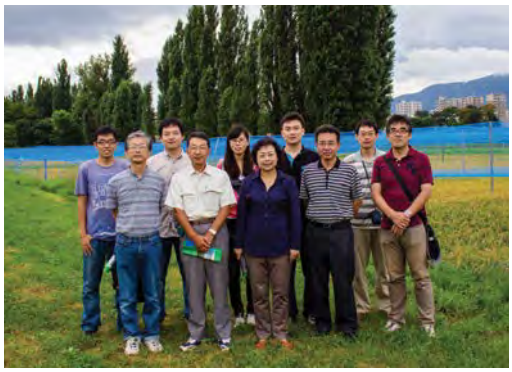

Figure 3. Project members visiting the farm at Hokkaido University.

Figure 4. Workshop on "Biochar and Environment."

Investigation into the Current State of Agricultural Waste Biomass Recycling in Tianjin

Based on statistical data in 2011, it was estimated that approximately 2,000,000 metric tons of agricultural straw was generated in Tianjin suburb. Currently, about 70% of the waste straw is reutilised, mainly as fertiliser, feed, base for producing edible fungi, and raw material for producing paper. In some towns, agricultural straws are not recognised as a resource but only as a waste; hence the knowledge dissemination on recycling this resource should be strengthened. There is also a need to further diversify the utilisation patterns of waste straw and to strengthen the conversion of biomass into energy.

Field Visits

In September 2012, we visited Hokkaido and Tokyo to investigate the reutilisation of biomass and biochar in Japan, accompanied by Professor Morita and Professor Matsuda, the Japanese members of this project. The following visits were made:

1. An experimental farm at Hokkaido University, where there were several devices for biomass waste recycling. For example, a pellet fuel was produced from tomato stems, which could be burnt to generate heat;
2. The Recycling Center of Furano City in northern Hokkaido. Reusable materials, such as bottles, metals, and worn clothing, were separated from the solid waste for reuse. The remnants that could not be recycled were pressed into solid fuel;
3. Shimokawa, a town in northern Hokkaido, where there are large areas of forests and plenty of biomass resources. We visited some facilities that burn wood for power and heating, and a factory that produces charcoal and biochar from woody biomass; and
4. An experimental farm at The University of Tokyo, where we investigated research on producing alcohol from plants for energy (Figure 3).

Dissemination Activities

A workshop on "Biochar and Environment" was held on 13 April 2013 (Figure 4). Over sixty participants (farmers, students, government officers and participants from the private sector) took part in the workshop and Prof. Sun gave a presentation and disseminated workshop material. A website, which was created to expand dissemination and increase awareness on biochar (www.shengwutan.icoc.cc, in Chinese), was also highlighted.

Project Publications

A monograph titled "Biochar and Environment" in Chinese is being edited by the publisher and will be published by Chemical Engineering Publisher, China. Several journal papers have been published

or are under preparation:

Li, L., Lu, Y., Liu, Y., Sun, H., & Liang, Z. (2012). Study on the adsorption mechanisms of Cd (II) by corn straw biochar. *Journal of Agro-Environment Science*, *31*(11), 2277–2283.

Zhang, P., Sun, H., Yu, L., & Sun, T. (2013). Adsorption and catalytic hydrolysis of carbaryl and atrazine on pig manure-derived biochars: impact of structural properties of biochars. *Journal of hazardous materials*, *244-245*, 217–224. doi:10.1016/j.jhazmat.2012.11.046

Zhang, P., Wu, J., Li, L., Liu, Y., Sun, H., & Sun, T. (2012). Sorption and catalytic hydrolysis of carbaryl on pig-manure-derived biochar. *Journal of Agro-Environment Science*, *31*(2), 416–421.

Zhang, W., Sun, H., & Wang, L. (2013). Influence of the interactions between black carbon and soil constituents on the sorption of pyrene. *Soil and Sediment Contamination: An International Journal*, *22*(4), 469–482. doi:10.1080/15320383.2013.733442

Sun, H. (n.d.). Effect of biochar and straw on plant productivity tissue and soil nitrogen nutrient status. Under preparation.

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Jablonowski, N. D., Borchard, N., Zajkoska, P., Fernández-Bayo, J. D., Martinazzo, R., Berns, A. E., & Burauel, P. (2013). Biochar-mediated [14C]atrazine mineralization in atrazine-adapted soils from Belgium and Brazil. *Journal of agricultural and food chemistry*, *61*(3), 512–516. doi:10.1021/jf303957a

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Assessment and Promotion of Japanese Strategies and Techniques for Biomass Recycling in Countryside of China — Concentrating on Agricultural Straw Residues

COUNTRIES INVOLVED

China, Japan

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