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Author(s)	Hairani, Anna
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学位論文内容の要旨

博士の専攻分野名称：博士（農学）　　氏　名：Anna Hairani

学位論文題名

Effect of biochar application on soil and plant

（バイオ炭施用が土壌および植物生育に及ぼす効果）

There is an urgency to establish effective agricultural management practice to increase food production while preventing the negative agricultural impacts on the environment. One such approach is the use of biochar. Biochar is a product of thermal degradation of organic material under oxygen-limited condition, similar in its appearance to charcoal produced by natural burning but distinguished by its use as soil amendment. Biochar has unique properties that expected to be a valuable soil amendment to sustainably increase soil health and productivity, as well as an appropriate tool for sequestering carbon in soils for the long term.

Biochar is widely used as a soil amendment to increase crop yields, but its effects on the dynamics of microbial communities and minerals in soils has not been fully elucidated, particularly in soils with organic manure application. On the other hand, application of biochar for mitigating greenhouse gas (GHG) emission from paddy and upland soils has been studied extensively. However, there was little information reported on the effect of biochar on GHG emission from soil in converted paddy fields which may have different characteristics of microbial community compared with general upland soil. Considering those points above, two experiments was conducted. Firstly, a pot experiment was carried out to examine the effect of biochar on microbial community structure and mineral availability in soils growing different crop species under different organic manure treatments. Secondly, an incubation experiment was set up in order to investigate the potential effect of different types of biochar application on GHG emissions and soil properties under different soil moisture conditions using soil from rice paddy fields.

1. Effect of biochar application on mineral and microbial properties of soils growing different plant species

A pot experiment was conducted using soybean and sorghum under four combination soil treatments (cattle farmyard manure with or without biochar and

rapeseed cake with or without biochar) to examine the effect of wood biochar on microbial community structure and mineral availability in soils. Growth of both species was improved by the biochar application, particularly in sorghum with rapeseed cake application. Principal component analysis using the data of Biolog EcoPlate^{TM} indicated that biochar application changed the microbial community structure in soil, particularly in soil grown sorghum. Biochar application had little effect on the profile of ammonium acetate-extractable mineral elements in soil with both types of manure application in soybean. In sorghum, however, biochar application altered the profile of the extractable elements in soil with rapeseed cake. This alteration is mainly due to the increase of the extractable concentration of some metals in soils. By contrast, concentrations of these metals in leaves of sorghum grown in soil with rapeseed cake did not change or tended to be decreased by the biochar application. Because biochar application increased microbial activity in soils with rapeseed cake, estimated by the average well color development in Biolog EcoPlate, biochar application possibly enhanced organic matter decomposition in soil with rapeseed cake producing chelating organic compounds that can solubilize some metals but make them less available for sorghum root. These species-specific changes in soil properties by biochar application may be related to the superior growth in sorghum with rapeseed cake.

2. Effect of wood and bone biochars on greenhouse gas emission of paddy soil under waterlogged and upland conditions

A soil incubation experiment was conducted with the following treatments: soil treated with and without manufactured biochar (wood and animal bone) at two soil moisture conditions (waterlogged for simulating paddy field condition and 60% of the field water capacity for simulating upland field condition converted from paddy field). During the incubation, production of CO_2, CH_4, NO, and N_2O emissions from soil in each treatment were determined. Average over two different soil moisture conditions, biochar addition significantly decreased the cumulative emission of CO_2, NO, and N_2O from the soils by 16%, 15%, and 30%, respectively, while enhanced CH_4 emission by 2.3 times as compared with those without biochar. Wood biochar was more effective than bone biochar in reducing CO_2, NO, and N_2O emissions. Different soil moisture conditions significantly influenced CH_4, N_2O and NO emissions, while did not CO_2 emission. A greater cumulative of CH_4 and N_2O and smaller NO emissions were observed in soil at waterlogged conditions than in soil at 60% FWC conditions for each biochar treatment. Interestingly, bone biochar application enhanced CH_4 emission more markedly under waterlogged conditions.